Edited by
Kakali Mukhopadhyay

Economy-Wide Assessment of Regional Policies in India

Applications of E3-India Model

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Foreword

In 2020 the world was struck by the COVID-19 pandemic. Economies around the world were forced to partially shut down, with major impacts on human welfare in both developed and developing countries. The pandemic showed the world that we cannot take business as usual for granted.

As severe as the effects of the pandemic were, the impacts of climate change could be far worse. Even while the world focused on COVID-19, new records were being broken around the world on both global temperatures and the impacts of climate change, including wildfires and tropical storms.

We may never find out if human behaviour was the root cause of the COVID-19 pandemic, but the fact that humans are responsible for climate change is beyond scientific doubt. Moreover, there is still time to stop the worst effects of climate change, although time is rapidly running out.

What happens in India will be critical to the world's efforts to limit the effects of climate change. However, India's role in the global economy will also grow in the coming decades. India will soon become the largest country in the world by population and its population could exceed 1.5 billion people by 2030. The Indian economy needs to grow to support employment for these people, while simultaneously increasing incomes and reducing poverty.

The direction of this economic growth will be important. A larger economy will need more energy. As long as this energy demand is met by fossil fuels, and especially coal, India's environmental footprint will continue to grow. But it does not have to be this way. Falling costs for renewable and electricity-based technologies mean that the transition to a low-carbon energy system may not be as expensive as initially feared. Indeed, electricity from some renewables has become cheaper than that from coal. Furthermore, investment in new equipment will create jobs in India; as this book shows, establishing a domestic sector to produce capital goods is a strategic goal for India. There will likely be a strong role for digital industries in this process.

It must be stressed, however, that many of these desirable changes will not happen without policy intervention. In India much of the power to create these policies lies at state level, but so far the necessary intervention has not been forthcoming. There are many reasons for the lack of policy, but one that stands out is that policymakers have not had access to estimates of social and economic impacts of potential policies within their states. If all you can see is unquantified risk, the safest option may be to do nothing.

This is where the E3-India model comes in. E3-India is an ambitious new tool that provides estimates of policy benefits and costs, at state level in India. It is based on a long tradition of modelling tools that can be traced back to the work of the Cambridge Growth Project at the University of Cambridge in the 1960s. The book explains how the state economies interact with their energy demands and supplies at a detailed sectoral level. It includes an account of how the data sources have been used to estimate industrial and consumer behaviour.

This book presents some of the early findings from the model. It includes a range of sectoral analyses covering agriculture & food, the digital economy, automobiles, other capital goods, and energy. These sectoral analyses are complemented by further results that show how the states of India can make their contribution to economic development, in a post-COVID-19 world, for example by maintaining high employment levels, increasing incomes and continuing to reduce poverty. The book also shows how this growth can be achieved while limiting impacts on the climate and local air quality.

The results in this book are of interest to researchers and policy makers alike. Interested researchers may use the model to carry out their own analyses, building on the examples in this book. The combination of this book and the E3-India model provide a solid platform for developing a low-carbon, sustainable pathway to future prosperity in India.

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Preface

In 2015, the NITI Aayog released India's first-ever roadmap for renewable electricity for India that comprehensively described the barriers faced by renewables and presented policy ideas to address them. During the roadmap development process, amongst many, a couple of profound issues were raised by policymakers and stakeholders:

- One of the key benefits of a significantly higher share of renewables in the Indian electricity portfolio was the potential elimination of coal imports that were valued, on average, at $15–20 Billion annually. In addition, a shift away from oil—mostly, imported—to electricity-based transportation would also lead to a similar massive reduction in India's import bill. It was unclear—though—who in India would be the direct and indirect beneficiaries and what their share of the benefit would be.
- As is the case with the uneven distribution of coal in India—mined, primarily, in just five central/eastern states—renewable electricity potential is also unevenly distributed, primarily, in the western and southern states. The coal-producing states are relatively small and poor while the renewable-rich states are relatively large and wealthy. A shift from coal to renewable—consequently—could potentially further widen the gap between the poor coal-producing states and the wealthy renewable-rich states. It was unclear what the size and nature of the impacts on individual states would be.

Obviously, there are several Indian and foreign experts who conduct this kind of analysis. Policymaking, however, yields the best outcomes when it enables meaningful participation from policymakers and stakeholders in addition to reviewing high-quality academic research. In 2015, though, there were no tools available in the public domain—anywhere in the world—that would allow Indian policymakers and stakeholders to quantify the direct and indirect benefits and their distribution across various politically relevant categories such as states, economic sectors, income groups and others. In order to address this fundamental gap in evidence-based decision-making, in 2016, as the Director of the Regulatory Assistance Project's India programme, I launched the effort that has led to the creation of E3-India.

E3-India, the primary component of the analysis presented in this volume, provides a sophisticated yet transparent platform over which policymakers and stakeholders can test a wide range of policies in terms of key metrics such as economic growth, employment, consumption, income, environmental impacts and others. Not only does E3-India support energy and environmental policy analysis—for example, the two issues mentioned above—it also supports similar in-depth analysis of all key sectors of the Indian economy such as agriculture, industry, socio-economic development and others. In fact, in the middle of a global pandemic that has set back the Indian economy significantly, E3-India is a crucial tool for systematically evaluating policies that would not only revive growth at the aggregate level but also across regions equitably.

Today, it is with great pleasure, I present to you this volume that describes E3-India in detail and a diverse set of policy analyses that were developed using E3-India model. I congratulate Professor Kakali Mukhopadhyay for guiding the distinguished group of contributing authors in putting together this comprehensive assessment of major policies. Each paper is a major step forward in helping Indian policymakers' and stakeholders' ability to better understand the trade-offs resulting from policies impacting major sectors such as agriculture, industry, electricity, transportation and others. I hope the readers not only find the state-of-the-art research presented here valuable immediately in the context of the pandemic-induced economic slowdown but also serve as a starting point for refining these analyses and taking on new ones.

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Ranjit Bharvirkar
Ex-Principal
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Acknowledgments

This book is an extended synthesis from the Regulatory Assistance Project's (RAP), E3-India initiative for supporting evidence-based policymaking in India. However, the entire responsibility of the content and analysis presented in the book is solely of the authors and does not necessarily represent the official view of RAP. RAP is not responsible for any liability in association with this content. The authors gratefully acknowledge RAP for partly funding the edited volume.

I am extremely grateful to the Cambridge Econometrics team for their relentless academic support. I remain indebted to Ranjit Bharvirkar (Ex-Principal, Regulatory Assistance Project, USA) who played an instrumental role in introducing me to the E3-India model and inviting me to work on the same. I would also like to thank Surabhi Joshi, Advisor and Consultant, Project Coordinator E3-India, who has helped me greatly during the E3 India model development.

My special gratitude goes to Dr. Shailja Sharma, Director General (Statistics), MOSPI, GOI and the SUT unit of National Accounts Division (NAD) for their support while preparing the E3-India model and insights while preparing the manuscript. I also extend my earnest acknowledgement to P. Bhanumati, Deputy Director General (Statistics), MOSPI, GOI and for her support while preparing the E3-India model.

The findings of the earlier version of few studies have been presented in various international conferences (53rd Annual Conference of the Canadian Economic Association (2019), Alberta, 27th International

Input-Output Conference (2019), Glasgow and the 2019 MIT (Massachusetts Institute of Technology) Applied Energy "A+B" Symposium, Cambridge). The authors are thankful to the participants of these conferences for their comments and suggestions which have contributed to the improvement of the respective chapters.

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She has numerous publications in peer-reviewed journals of international repute. She has authored six books in various fields of energy, environmental pollution, trade and I-O modelling. She has completed several studies on behalf of the United Nations Environment Programme, UN-ESCAP, UNCTAD, Asian Development Bank, ERIA-Indonesia, Shastri Indo-Canadian Institute, Public Health Agency of Canada, Genome Canada and Genome Quebec, Agriculture and Agri-Food Canada, BioFuelNet Canada, West Bengal Renewable Energy Development Agency, Indian Council of Social Science Research and South Asian Network for Development and Environmental Economics—SANDEE.

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Hector Pollitt is the Head of modelling at Cambridge Econometrics, Cambridge, UK. He leads the E3ME project which is a global, econometric model that is designed to address major economic, social and environmental challenges that the world is facing. He has worked with the model for more than 15 years. He has contributed to several high-profile

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Abbreviations

ACMA	Automotive Component Manufacturing Association
AEP	Agriculture Export Policy
AMP	Automotive Mission Plan
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APEDA	Agricultural and Processed Food Products Export Development Authority
APMC	Agricultural Produce Market Committee
APPC	Average Power Purchase Cost
ASEAN	Association of South East Asian Nations
ASI	Annual Survey of Industries
BAU	Business as Usual
BCS	Baseline Capacity Scenario
BEE	Bureau of Energy Efficiency
BS VI	Bharat stage VI
C&I	Commercial and Industrial
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CAQM	Commission for Air Quality Management
CCS	Carbon Capture and Storage
CEA	Central Electricity Authority
CG	Capital Goods
CGE	Computable General Equilibrium
CII	Confederation of Indian Industry
CMA	Cement Manufacturers Association
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide

COP	Conference of the Parties
COVID	Corona Virus Disease
COVID-19	Corona Virus Disease 2019
CPCB	Central Pollution Control Board
CSO	Central Statistics Office
DBT	Direct Benefit Transfer
DGCIS	Directorate General of Commercial Intelligence and Statistics
DISCOM	Distribution and Transmission Companies
EEPC	Engineering Export Promotion Council of India
EPCG	Export Promotion Capital Goods
EPF	Employee Provident Fund
EPFO	Employee Provident Fund Organisation
EPWRF	Economic and Political Weekly Research Foundation
ETC	Energy Transition Commission
EU	European Union
EV	Electric Vehicle
EY	Ernst & Young
FAME	Faster Adoption of Manufacturing of (Hybrid) Electric Vehicles
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FE	Financial Express
FGD	Fuel Gas Desulphurization
FICCI	Federation of Indian Chambers of Commerce & Industry
FOB	Free on Board
FPI	Food Processing Industry
FSI	Forest Survey of India
FTT	Future Technology Transformation
GDI	Gross Disposable Income
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GOI	Government of India
GRAP	Graded Response Action Plan
GVA	Gross Value Added
GVCs	Global Value Chains
GVO	Gross Value of Output
GW	Gigawatts
HRES	High Renewable Energy Scenario
IBEF	India Brand Equity Foundation
ICE	Internal Combustion Engines
ICT	Information and Communication Technology
IDA	International Development Association
IEA	International Energy Agency

IFC	International Finance Corporation
IHDS	Indian Human Development Survey
IIP	Index of Industrial Production
IMF	International Monetary Fund
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
IRDA	International Bank for Reconstruction and Development
IT-ITeS	Information Technology-Information Technology Enable Services
IV	Instrumental Variables
KUSUM	Kisan Urja Suraksha evam Utthan Mahabhiyan
LCOE	Levelized Cost of Electricity
MECON	Metallurgical & Engineering Consultants (India) Limited
Mn	Million
MNCs	Multinational Corporations
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MOFPI	Ministry of Food Processing Industries
MOSPI	Ministry of Statistics and Programme Implementation
MPCE	Monthly Per Capita Expenditure
MSME	Micro, Small and Medium Enterprises
MSPs	Minimum Support Prices
MT	Million Tonnes
NABARD	National Bank for Agriculture and Rural Development
NATRIP	National Automotive Testing and R&D Infrastructure Project
NBFC	Non-Banking Financial Institutions
NCO	National Classification of Occupation
NCR	National Capital Region
NCT	National Capital Territory
NDC	Nationally Determined Commitments
NEMMP	National Electric Mobility Mission Plan
NIC	National Industrial Classification
NITI	National Institution for Transforming India
NMFI	National Mission for Financial Inclusion
NOx	Nitrogen Oxides
NPA	Non-Performing Assets
NRAI	National Restaurants Association of India
NSDC	National Skill Development Corporation
NSP	National Steel Policy
NSSO	National Sample Survey Office
NSTMIS	National Science and Technology Management information System
OEM	Original Equipment Manufacturers

OLS	Ordinary Least Squares
PFC	Power Finance Corporation
PIB	Press Information Bureau
PM	Particulate Matter
PMJDY	Pradhan Mantri Jan Dhan Yojana
PMKSY	Pradhan Mantri Krishi Sinchayee Yojasna
PMMY	Pradhan Mantri Mudra Yojana
PMP	Phased Manufacturing Programme
PRS	PRS Legislative Research
PV	PhotoVoltaic
PWC-FICCI	PricewaterhouseCoopers—Federation of Indian Chambers of Commerce & Industry
R&D	Research and Development
RBI	Reserve Bank of India
RE	Renewable Energy
RGDI	Regional Gross Disposable Income
RVCs	Regional Value Chains
SARS	Severe Acute Respiratory Syndrome
SDGs	Sustainable Development Goals
SESEI	Seconded European Standardization Expert in India
SEZs	Special Economic Zones
SIAM	Society of Indian Automobile Manufacturers
SMEs	Small and Medium Enterprises
SO_2	Sulphur Dioxide
TPP	Thermal Power Plants
UAE	United Arab Emirates
UDAN scheme	Ude Desh ka Aam Naagrik Scheme
UDAY	Ujwal Discom Assurance Yojana
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollars
WSA	World Steel Association

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CHAPTER 1

Introduction

Kakali Mukhopadhyay

India is one of the fastest-growing trillion-dollar economies. With several notable reforms in the past, the country has emerged as a prominent player on the global front. Moving forward, the country aspires to become a five trillion-dollar economy by the year 2024–2025 and subsequently a ten trillion-dollar economy by the year 2030 (ET Now, 2020). With ample evidence to prove that India's growth has been highly unequal in the past (Chancel & Piketty, 2017), transforming this vision into reality will require a comprehensive approach based upon a multitude of policies targeting multiple domains, capable of tackling the key problems that India is facing currently. These include rising unemployment, dwindling GDP growth, lagging social sector development, the inevitable consequences of climate change and the prevailing COVID crises.

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While targeting these key problems is crucial, it is equally important to leverage the unique opportunities available to the country. With a population of 1.3 billion, India has one of the youngest populations in the world. The window of demographic dividend in India is supposed to last until 2055–2056 (Thakur, 2019), longer than most other countries in the world. Advantages associated with the demographic dividend include better economic growth, rise in female labour force participation as well as rapid industrialisation and urbanisation. India's biggest opportunity, therefore, lies in its youth. However, uncapping the potential of this demographic dividend would entail careful policy intervention to create opportunities for absorbing an increasingly youthful workforce. Any failure to do so would convert this opportunity into a major impediment to the economy's structural transformation.

Both theory and international experience suggest that an economy's structural transformation entails reorientation of the sector wise contribution to Gross Domestic Product (GDP) as well as their concomitant share in the labour force. Conventionally the share of the primary sectors like agriculture decline first in GDP, followed by employment, thereby making way for the corresponding rise in the share of the non-agricultural sectors. A turning point is reached when the share of the primary sector in the work force starts to decline faster than its share in GDP however, in the Indian context, this turning point still seems distant. A major reason for this has been the inability of the Indian manufacturing sector to generate sufficient opportunities to drive rural–urban migration at the expected pace, primarily due to lack of resources, poor infrastructure and lack of skilled labour for high-end manufacturing. Consequently, the Indian economy has been on a path less travelled where the tertiary sector bypassed the secondary sector to become the largest contributor to the GDP, while the agricultural sector retained its position as the largest source of livelihood, despite its declining share in the GDP.[1]

With a large section of the workforce bottled up in the agricultural sector and the poverty levels worsening, a successful structural transformation and optimal utilisation of the existing demographic dividend

[1] The estimated share of primary (comprising agriculture, forestry, fishing and mining & quarrying), secondary (comprising manufacturing, electricity, gas, water supply & other utility services and construction) and tertiary (services) sectors in India was 18.57, 27.03, and 54.40% in the year 2019 (Statistics Times, 2019).

opportunity will require improving agricultural productivity, strengthening the manufacturing base and sustaining the current growth of the services sector. With these objectives in mind, the Government of India has announced numerous policies ranging from agriculture to services, science and technology, energy consumption and environmental pollution. To have a realistic picture of the growth trajectory, it is important to understand the direct and indirect implications of any policy both in the short run as well as the long run. Although, as important as it may seem, it is an equally complex task to grasp even a thin directional indication from a plethora of policies being announced across sectors simultaneously. Each sector in turn demands attention towards its numerous specific and unique aspects, resulting in further proliferation of policy choices. Moreover, apart from serving as a framework for achieving the country's growth targets, the formulated policies should also accommodate India's commitments towards achieving Sustainable Development Goals (SDGs) and the existing obligations under the Paris Agreement. Nevertheless, the magnitude of policies is not the only reason for concern. The intricacy is further enhanced by the regional variation that India possesses. To realise any national target, each state and Union Territory lays down a series of interventions depending upon its endowments, capability, competitive edge and developmental aspirations. Additionally, every state tends to possess certain key sectors, such as the tourism sector in Kerala or agricultural sector in Punjab, depending upon which the policy mix varies from state to state. Since sectoral implications are often geographically specific, understanding region-specific implication of any micro or macro policy shifts are really important for further fine tuning.

In the fast-changing policy landscape of a country as diverse as India, gauging regional implications of policy shifts has become all the more important to understand the direction and distributional impacts of ongoing policies. This requires application of advanced analytical tools capable of capturing sector-wise implications of policy shocks at the regional level both in the short run and the long run. E3-India model is one such model which provides its users with a framework which is versatile, modular and can be easily integrated into assessments and evaluations for real-time policy analysis both at the regional and national levels. The model can hence play an instrumental role in measuring the most comprehensive regional impacts of policy shifts.

The E3-India model is a state level model developed on the internationally recognised E3ME global model framework.[2] It includes 28 Indian states along with 4 Union Territories where each state is further broken down into 38 sectors. A high level of disaggregation enables a detailed analysis of sectoral and country-level effects for a wide range of scenarios. It maps inter-linkages of the economy and energy sector as it accounts for 21 energy users of 5 different energy carriers and subsequent CO_2 emissions. Unlike the more common computable general equilibrium (CGE) approach to economic modelling, E3-India does not assume full employment or perfectly competitive markets; instead, it estimates behaviour based on available historical data. Its econometric specification addresses concerns about conventional macroeconomic models and provides a strong empirical basis for policy analysis.

This book is a compilation of articles that employ E3-India model as an economic impact analysis framework for policy recommendations by assessing policy implications—both benefits and costs—accruing to the nation and their distribution across states. The commonly used econometric models for policy analysis are restrictive in terms of not being able to provide inter-linkages of key economic indicators, thereby limiting the scope of the study to the inputs provided. However, the E3-India model has an inbuilt feed of best available data, collected and compiled from various sources with internal consistency which expands the possibilities for analysis, specifically through mapping of the input–output relationships dynamically.

The econometric pedigree and empirical grounding of the model make it better able to represent performance in the short to medium term, as well as providing long-term assessments until the year 2035 without being too reliant on rigid assumptions. The E3 linkages, and the hybrid nature of the model address the non-linear interaction between the economy, energy demand/supply and environmental emissions. This is an undoubted advantage over other models. It provides a platform for easy comparison of the future projection with that of the base-level model. The model also represents best practice for sectoral policy simulations. It allows an understanding of the policy framework and its progress within a state and hence, can be used for the national level policy framework and for any corrective measures to be undertaken before the target year.

[2] E3ME website: https://www.e3me.com/.

By presenting a range of sector-specific studies evaluating the effectiveness of some important policy shocks, this book provides a realistic outlook of the economic sensitivities at a regional level by focusing on interdependencies both at the national and state-level across India. This broadens the scope for the future course of action by reducing the ambiguity and uncertainty in the possibilities of achieving the targets. Based on the estimations and methodology provided in these studies, policy makers can evaluate the efficacy of current policies and also come up with alternatives for better developmental outcomes by designing multiple alternate policy scenarios using the model.

We begin the discussion by introducing the readers to the theory behind the E3-India model, followed by an elaboration on data construction and its sources. This is followed by sector specific policy impact assessment studies from chapters four through ten. The broad themes covered in this book have been carefully selected to touch upon the key areas that are instrumental to the growth of the country. In order to provide realistic insights into the current state of affairs, care has been taken to account for the impact of the COVID-19 pandemic for all the sectors dealt in the chapters. We begin the sector specific studies with the Agriculture and allied sectors in Chapter 4. This sector forms the backbone of the Indian economy. This chapter also discusses the major national and regional policies for the food processing sector, which with its unique ability to link the primary sector (agriculture) with the secondary and tertiary sectors has emerged as a 'sunrise' industry in the country. The main national scenarios discussed in this chapter are with reference to the Agriculture Export Policy 2018 and the projected growth of the National Food Processing Industry (FPI). In addition to these national policies, two regional policies are discussed for the states of Uttar Pradesh and Rajasthan. Overall, the results suggest that the key state that drives agricultural exports is Gujarat. However, in the case of the FPI, the results are not so straightforward, with different states standing to gain in terms of different economic indicators. The analysis of regional policies provided greater insights into the factors constraining the performance of the respective states in these sectors.

After addressing the primary sector, the focus shifts to the secondary sector. National policies related to the secondary sector are discussed in chapter five which focuses exclusively on the Capital Goods sector. By virtue of strong linkages possessed by this sector, a resilient capital goods industry can catalyse productivity in multiple sectors across several domains, thereby making the sector strategically important for the economic independence of the country. On evaluating the prospects of the capital goods sector at a regional level under three major national policies related to the sector, viz., the National Capital Goods Policy 2016, the National Steel Policy 2017 and the Electrical Equipment Mission Plan 2012–2022, it is found that only three states viz., Maharashtra, Karnataka and Haryana, are able to reap the adequate benefits from these policies. The chapter also provides evidence on the potential of smaller states like Chhattisgarh, Odisha and Jharkhand, which can benefit immensely from similar policies replicated at the regional level that is tuned to suit their current level of development. At the same time, the sub-optimal performance of major states in terms of employment generation is also highlighted. In addition to this, the chapter also critically assesses Government of India's push for Import Substitution and Export Promotion in the capital goods sector by highlighting the capital constraints that have plagued the sector for some time.

Having touched upon one of the most crucial components of the secondary sector, attention is directed towards technologically advanced sectors in manufacturing and service domain, the Electronic System and Design Manufacturing (ESDM) sector and the IT sector. Technological advancement has revolutionised the way goods are manufactured, and services are delivered which makes these sectors highly critical for maintaining competitive edge. In this context, Chapter six discusses the National Policy on Electronics, 2019, the Digital India initiative and the National Software Policy (2019). Additionally, state-level policies related to these sectors are evaluated for the states of Uttar Pradesh and Rajasthan. The results reveal that Delhi, Tamil Nadu and Uttar Pradesh are benefitted by both, the electronics scenario as well as the IT-ITeS sector scenarios. However, the impact of the IT sector policies has had a larger and far-reaching impact on the Indian economy compared to the Electronics sector policy. The results also indicate that even after the implementation of government IT policies, the sector remains a net importer of software products.

Another major segment of the manufacturing sector addressed in the book is the automobile sector. India's automobile industry is the fifth largest in the world, contributing 7.5% to the national GDP. The sector has been subject to frequent policy reforms mainly accruing to the implementation of revised fuel standards. Chapter seven explores the regional implications of the recent Automotive Mission Plan 2026, in the context of the structural changes in terms of localisation of component manufacturing and implementation of BS VI fuel standards. Further, as this is one of the most energy intensive sectors, different states have formulated their own policies to accelerate the transition towards electric vehicles in the country. In this context, the chapter also evaluates sub-national Electric Vehicle (EV) policies for seven different states. The results indicate that Haryana and Tamil Nadu have been the largest beneficiaries of Automotive Mission Plan 2026 policy while Karnataka and Maharashtra show promising results under their respective state-EV policies.

In light of the policies discussed in the chapters above, their impact on the environment and the country's natural capital seems inevitable. Therefore, Chapters 8 and 9 focus exclusively on energy and environment related policy reforms, which are critical for the sustainable growth of the Indian economy. Chapter 8 evaluates the regional energy-economy interactions in the context of India's target of achieving renewable energy (RE) capacity of 450 GW by 2030, along with the proposed reforms in cross-subsidisation strategies in the power sector as put forth by the Government of India through amendments to the Electricity Act 2020. This analysis is performed for nine key states representing a mix of diverse energy potentials. Results of this regional analysis reveal the underlying disparity in terms of the inherent potential of these states to adopt RE where the states with high economic growth and high RE potential viz. Tamil Nadu, Karnataka, Maharashtra and Andhra Pradesh show higher installation of RE capacity than the other five states taken into consideration. This is indicative of the fact that these five states require more effective policies and structural changes in the power sector to reap the benefits of the renewable energy transition. In addition to modelling four separate scenarios pertaining to expected expansion of renewable energy, reduction in energy intensity, power sector subsidy rationalisation and impacts of COVID 19, the chapter also presents an integrated scenario to account for the interaction between these scenarios which are expected to coexist. On analyzing the impact in terms of carbon intensity across states, this integrated scenario draws attention towards the need to create greater synergies between high renewable-efficiency targets and subsidy rationalisation without which the requisite environmental performance towards the Nationally Determined Commitment ratified under Paris Agreement by India cannot be achieved.

Chapter 9 further extends the policy impact discussion on the environmental front by assessing how coordinated regional policies for separate as well as integrated management of the major sources of air pollution viz., power generation, vehicular emissions, construction and agriculture sector in the four major states (Delhi, Punjab, Haryana and Uttar Pradesh) relevant in the National Capital Region (NCR) air-shed can help improve its air quality. Stylised scenarios for these sectors are developed to understand impacts of key interventions like increased renewable capacity scale up and installation of emission control equipment on thermal power plants, scaling up the use of Electric Vehicle (EV), periodic ban on construction activities and a portfolio of strategies to serve as an alternative to stubble burning in the agricultural sector. On evaluating these scenarios individually, the study finds that a periodic ban on construction activity results in a massive negative economic shock while a nationwide shift towards a High RE future for the Indian power sector proves to be the most conducive from both environmental and economic perspective. An integrated assessment of these scenarios suggests that the High RE and EV scenarios are mutually reinforcing and thus a combination of both successfully delivers better results across all socio-economic and environmental variables considered in the chapter.

Having addressed the critical element of energy-environment linkages for the Indian economy, Chapter 10 draws attention to India's efforts in tackling the unfortunate consequences of the COVID-19 pandemic through liquidity infusion. While the current pandemic has sent shockwaves across major sectors of the economy and all the sections of the population, its impact has been particularly acute on the small and medium enterprises as well as the economically vulnerable section of the population. In light of the economic havoc caused by the pandemic, Government of India announced a relief package worth INR 20 Lakh Crore (USD 285 billion) in mid-May under the tag of 'Atmanirbhar Bharat' (Self-reliant India) (PTI, 2020). This chapter provides a comprehensive assessment of the schemes announced under the Atmanirbhar 1.0 package through four different scenarios. These include credit support to Agriculture and MSME, social and physical infrastructure, direct income support and the liquidity infusion through Reserve Bank of India. It identifies the states performing well under various schemes and highlights the need for additional directives to support the social and physical infrastructure development in the regions lagging behind, especially in the North Eastern and hilly states. The credit penetration and financial services to the agriculture, manufacturing and services sectors would help in bringing benefits to the households through employment, growth in demand and provision of basic services. Furthermore, with the recent announcement of Atmanirbhar package 2.0 and 3.0, the chapter recommends that a periodical review of the impact of such liquidity infusion can help in understanding the magnitude and direction of government support required in future.

Finally, Chapter 11 summarises the findings of the constituent chapters of the book while highlighting the key take-away points from each of them. Additionally, the chapter provides a major value addition to the results of the previous chapter by undertaking an integrated scenario combining major policies discussed in the preceding chapters. The scenarios are developed for four different regions, North, East, South and West. The Northern region is represented by Haryana, Rajasthan and Uttar Pradesh. The Eastern region is represented by West Bengal and Odisha. The Southern region is represented by Andhra Pradesh, Karnataka and Tamil Nadu. The Western region is represented by Maharashtra and Gujarat. Such an integrated scenario can help answer questions regarding how these regions perform when multiple national as well as regional policies are at work simultaneously. The chapter provides interesting insights regarding the ability of states to deliver on the multiple targets set forth by numerous policies. Moreover, the main intention of this exercise is to identify the priority sectors for each zone which must be targeted in the short run to take leverage of the existing potential of the respective states which offer high returns in response to the stimulus provided by existing policies. After this, an inter-regional comparison of sectoral performance is undertaken to identify the sectors where the current returns are not commensurate with the amount of investment directed towards them. These sectors must be targeted from a medium to long run perspective by redirecting sufficient investment to ensure adequate capacity building of the region in order to be able to respond to national policies adequately.

As seen throughout the book, the outcomes of the E3-India model simulations are very clear, transparent and can be readily identified and explained. The most relevant application of this distinct feature is manifested in terms of quantifying regional performance across a multitude of indicators. By supplementing the results of the model in terms of the sector specific information on the areas where a particular state lags with the knowledge of factors contributing to the growth of best performing states in that particular area, effective regional value chains can be initiated and sustained through adequate knowledge transfer. Therefore, by evaluating the regional implications of policies concerning a wide range of vital sectors of the Indian economy and clearly outlining the short run as well as medium and long run priority sectors at a regional level, this book intends to provide a comprehensive outlook for evidence-based policy making in India.

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CHAPTER 2

Introduction to the E3-India Model

Hector Pollitt

2.1 Introduction

There is now a scientific consensus that policymakers must take action to limit ecological degradation and prevent future environmental disaster (IPCC, 2018). However, managing change is not easy for policymakers. If a new policy leads to job losses or social disruption, the policymaker will soon find him or herself out of a job. Especially, when many of the benefits of environmental policy will be realised long into the future, doing nothing is a much safer option.

Therefore, if environmental disaster is to be averted, policymakers must be confident that they can implement policies that will not lead to widespread discontent. In some cases, the policies can be trialled (e.g. in certain local areas) but, usually, real-world experiments are not possible. Computer modelling offers the next best alternative.

The E3-India model, which is used in most of the chapters of this book, was designed to provide a tool to carry out such experiments. The model is used to simulate the effects of economic and energy policy

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within India, providing the information that policymakers need when assessing the merits of new policy proposals. It builds on a previous global modelling framework called E3ME that is now well established in the policy community (Cambridge Econometrics, 2019; Mercure et al., 2019).

The model operates through a scenario-based approach. Throughout this book, policy shocks are introduced as either changes in prices or quantities, and the impacts of these shocks are compared to a baseline case.

E3-India is not the only tool that is intended to carry out policy analysis within India and the authors would not recommend relying on a single model. However, the model incorporates several important features that make it stand out from the other approaches available:

- E3-India divides India into 32 states and union territories. This is a significant feature because it reflects the structure of policymaking within India, with many areas of policy determined at state level. It also captures the different endowments of natural resources across the country.
- The model is designed explicitly to capture interactions between the economy and the energy system in each state. Changes in physical energy consumption are matched against changes in economic production, providing a consistent analytical basis. E3-India also includes an advanced model of technology diffusion in the critically important electricity sector.
- Within each state, the economy is divided into 38 sectors. This disaggregation of economic activities allows policies to be assessed at sectoral level (as many chapters of this book do) and similarly can represent impacts at a relatively high level of detail.
- The model is highly empirical in nature, using econometric techniques to represent human behaviour. Its post-Keynesian economic foundations are based on observations of how the economy and financial system work (see Sect. 2.3).

E3-India can be used to assess both the short- and long-term effects of policies. It provides estimates of impacts on an annual basis up to the year 2035.

The next section describes the basic structure of the model. Section 2.3 discusses the economics of the model and compares it to the more common computable general equilibrium (CGE) approach. Section 2.4 summarises the key messages from this chapter. The appendices give further technical information about the model and guidelines for the reader to obtain their own version.

This chapter is intended to provide only a summarised description of the model. Subsequent chapters will provide further details that are relevant to their particular applications. Further resources and the full model manual are available from the model website.[1] It is also possible to download the full model through the website and test further scenarios.

2.2 Basic Model Structure

2.2.1 Introduction

The E3-India model is split into three different modules: Economy, Energy and Emissions (see Image 2.1). The acronym for the model name is derived from the initials of these modules. The figure shows how the different modules interact with each other. As each module uses different units, it is necessary to ensure consistency by matching levels with growth rates in a similar way to how systems dynamics modelling works.

Technology sits at the core of the modelling approach and may influence the outcomes from all the different modules. There is a general consensus that technological development is a key driver of long-run economic growth. However, the choices of technology used may also determine the amount of energy used (and from which fuel it comes) and related environmental emissions.

A short summary of each module is provided below.

2.2.2 The Economy Module

The Economy module is the largest of the three main modules. The Economy module provides both an accounting framework that is consistent with national accounting conventions and a representation of human behaviour through its econometric equations. A list of both sets of equations is provided in the model manual and in Appendix II of this chapter.

[1] https://www.e3indiamodel.com/.

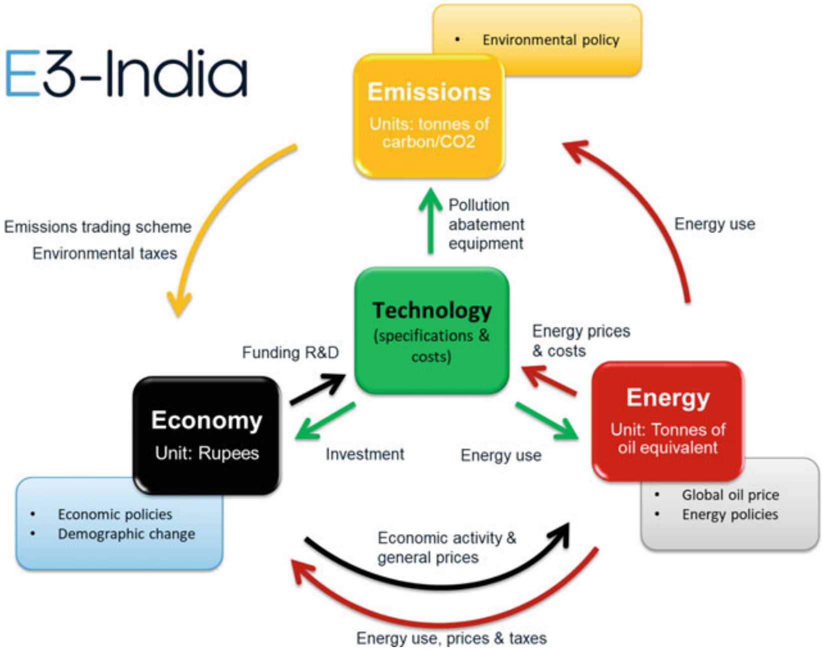

Image 2.1 E3-India model structure (*Source* E3-India manual)

Examples of the accounting identities include the standard demand-side equation for GDP:

$$GDP = C + I + G + X - M$$

In which, GDP is equal to the sum of consumption, investment, government final consumption and net trade. An example of an econometric equation is:

$$I = a + b1 * Y + b2 * PI + b3 * IR + e$$

In which investment (I) is a function of production (Y), relative investment prices (PI) and the interest rate (IR). The parameters a and b1 to b3 are elasticities that are estimated using econometric techniques (see below) and e is an error term.

Most calculations in the Economy module are carried out at the sectoral level within each state, with aggregate indicators such as GDP determined by summing across the sectors (and states to get to national level). Most of the econometric equations are estimated and solved at sectoral level.

The 38 sectors in the model are linked by input–output coefficients that describe the intermediate purchases between the different sectors. Thus, supply chains are well represented in the model. Interactions between the different states and territories of India are represented by a bilateral trade matrix.

There are several recursive ‘loops’ within the Economy module that can lead to Keynesian multiplier effects. For example, higher incomes lead to increased household expenditure and revenues for shops that in turn pay higher wages, boosting incomes further (see Image 2.2). Other loops include the linkage between investment and output, which represents Keynesian ‘animal spirits’ and the trade loop that shows how one

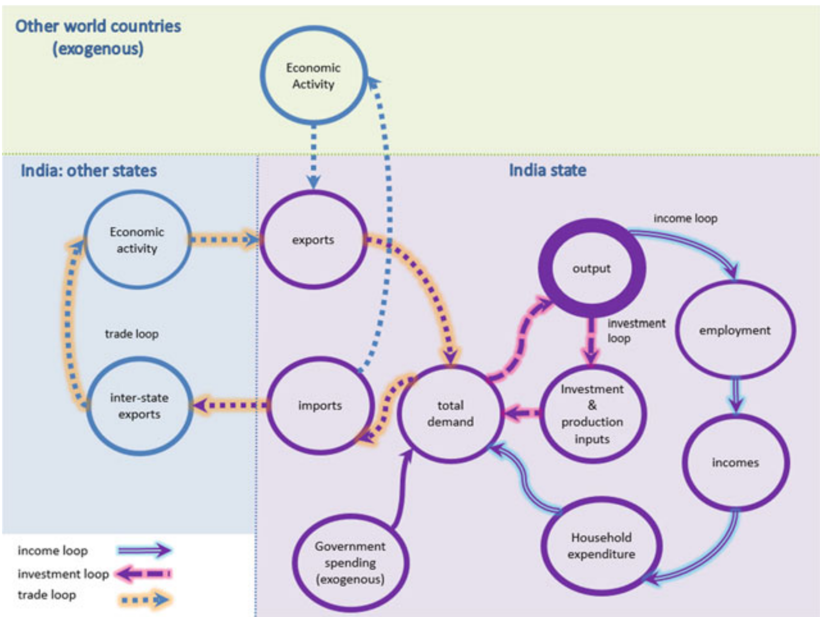

Image 2.2 Main economic flows in E3-India (*Source* E3-India manual)

state expanding production can pull its neighbours along too, which then feeds back to the first state. These loops are important both for understanding the current dynamics of the economy, but also as a source of economic growth.

Prices, both of energy goods and in the wider economy, are determined in the Economy module. There are also equation sets for employment and labour supply. Unemployment, a key indicator for policymakers, is determined as the difference between employment and labour supply.

As Image 2.1 shows, the Economy module is closely connected to the Energy module (see below) through two-way interactions. The Economy module provides estimates of demand to the Energy module which, in return, provides estimates of activity in the energy sectors (e.g. electricity supply). Feedback from the environment module may also affect prices in the economic module if an emissions tax is imposed.

There is also an important interaction between technology and the Economy module. The direction and pace of economic growth determines the level of technological growth. The state of technology in each sector, in turn, affects several of the model's econometric equations, including prices, trade and employment.

2.2.3 The Energy Module

The Economy module feeds measures of demand into the Energy module; if rates of economic production increase then the demand for energy will also increase (although not necessarily in proportion). Within each sector, energy demand is estimated first at an aggregate level and then broken down to energy carrier (i.e. fuel type). The model thus allows for switching between different types of fuel in production.

Both total energy consumption and the choice of fuel are also dependent on relative prices within each state. Energy prices in India are determined by international commodity prices plus any taxes or subsidies that are levied. Electricity prices are determined within the E3-India model (see below).

The Energy module also provides feedback to the Economy module, through the energy sectors that are defined within the model. For example, if the demand for electricity increases, economic production by the electricity production sector will increase. The sector will also be likely to increase its employment levels, creating further economic impacts.

As described below, rates of energy consumption are passed to the Emissions module.

In scenarios that aim to limit future greenhouse gas emissions, the choice of production methods used by the electricity production (i.e. power) sector is critical. The E3-India model therefore incorporates a more detailed treatment of the electricity sector, which is called Future Technology Transformations (FTT). FTT is based on innovation theory and tracks the diffusion of new technologies. The model produces the S-shaped curves that are common in innovation literature, as new products move from cautious early adopters to rapid uptake and finally market saturation.

FTT defines 24 different types of electricity production, including conventional (e.g. coal-fired) methods, nuclear, renewables and carbon capture and storage (CCS) options. It is described in more detail in Mercure (2012) and Mercure et al. (2014).

The FTT sub-model works from the perspective of investors in the power sector. When new electricity generation capacity is required, the investors must choose between the available technologies. They are likely to choose the tried and trusted technologies that they are familiar with; even if new technologies are cheaper, the level of risk in unknown technologies deters investors.

Over time, however, as new technologies become established, investors become more comfortable and are more likely to adopt these technologies. At the same time, economies of scale may make the new technologies cheaper. The result is a rapid increase in uptake, which is the steep part of the S-shaped curve. Eventually, most of the market is captured and growth slows.

FTT represents the relationships between the different technologies using pairwise differential equations that show rates of substitution between each technology. The key determining factors are existing market share of the new technology, cost and ease of transition (e.g. how similar the technologies are). It may thus be possible to find ‘bridging’ technologies that ease the transition, as gas-fired plants may do in the power sector.

The results from the FTT sub-model are important for the rest of E3-India. FTT determines the level of fuel demanded by the power sector and feeds this back to the main Energy module. It also determines levels of investment (fed back to the Economy module) and electricity prices (fed back to both the Economy and Energy modules). It therefore plays a central role in the analysis.

2.2.4 The Emissions Module

Energy consumption is converted into environmental emissions in the Emissions module. Each unit of fuel consumption is given an emissions coefficient, which is estimated in the final year for which data is available and is held constant over the period up to 2035. The level of emissions is dependent on both the level of total energy consumption and the choice of fuel used. In E3-India, leaving aside electricity, there are four fuel types: Coal, Oil, Natural gas and Biofuels. In the modelling, we assume a direct lifetime emission coefficient of zero for biofuels. Substantial emission reductions could be achieved by switching between the different fuels.

If there are taxes on emissions, this will influence both the choice of fuels used in energy consumption in the Energy module and have effects on the wider economy through higher costs that may be passed on to final product prices in the Economy module.

2.2.5 Technology in E3-India

In modelling frameworks, technology may be modelled as either 'bottom-up' (a list of technologies defined explicitly) or 'top-down' (a more aggregated approach). The FTT model in E3-India is an example of a bottom-up approach.

It is not possible to define every potential technology in every sector, so the rest of the model uses a top-down approach. The state of technology is defined as the knowledge stock, represented by accumulated investment within each sector.

The technology variable provides a measure of product quality in the Economy module. It feeds into several of the model's economic equations, including those for prices, trade and employment. It also affects energy demand, because more advanced products are more efficient.

2.2.6 Data and Baseline Projections in E3-India

In any modelling exercise, the results from the analysis will only be as good as the data that are used. Data quality is particularly important for econometric models. Substantial effort has therefore gone into compiling the E3-India model's database. The database covers the period 1993 to 2015 on an annual basis, with most variables in the model disaggregated both by sector and by state.

The main data sources in the model are from Indian Ministry of Statistics and Programme Implementation (MOSPI) and Indian National Sample survey reports (NSSO). However, other sources are also used. Further details on data sources and processing are provided in Chapter 3.

When carrying out *ex ante* analysis, it is necessary to have a business-as-usual baseline to which scenarios with additional policies are compared. This baseline case has been constructed by the modelling team, based largely on an extrapolation of previous sectoral growth rates that are constrained to match aggregate GDP projections.

A method of 'calibration' that involves scaling model results is used to ensure that the model baseline is consistent with the constructed baseline. The same scaling is applied to all model runs so that it does not affect the comparison between scenarios. At a conceptual level, it is similar to adjusting the intercept terms in the econometric equations described below. The calibration process is described in more detail in the model manual.

2.2.7 The Econometric Specification of the Equations

The accounting relationships in E3-India are determined by identity equations within the model; for example, as noted above, GDP is defined as the sum of its component parts. Where there is an element of human behaviour, however, it is necessary to adopt an econometric-based approach.

The model parameters make use of the time-series data that have been collected. There are 16 econometric equation sets in the model, each of which is disaggregated by state and by sector. The specification of each equation set is derived from the global E3ME model, with some terms removed to allow for use with shorter time series. The estimation approach is one of error-correction, as described in Hendry et al. (1984) and Engle and Granger (1987).

In short, the estimation is based on a two-stage least squares approach. At the first stage, there is a levels-based equation, which uses Ordinary Least Squares (OLS) to estimate long-run trends. The errors from this estimation are included as an additional term in the same regression but with each variable differenced (and a lag term included). This second estimation gives the short-run, dynamic effects and the estimated coefficient on the error term determines the speed of transition from short to long term.

Each equation thus produces a long-run, steady-state outcome but is subject to short-term shocks on a year-to-year basis. Importantly, what happens in the short term determines long-term outcomes and the model includes a strong element of path dependency. All estimation uses instrumental variables (IV) to capture the simultaneous nature of many of the relationships in the model.

2.3 Comparison to Other Modelling Approaches

An important difference between E3-India and most other macroeconomic models is its underlying economic specification. Developed in the Cambridge tradition, E3-India embodies post-Keynesian macroeconomic theory (King, 2015; Lavoie, 2015), which is substantially different to the neoclassical form of economics that is used in CGE models (Dixon & Jorgensen, 2012). Post-Keynesian economics developed out of John Maynard Keynes' *General Theory of Employment, Interest and Money* (Keynes, 1936), led initially by scholars such as Joan Robinson and Michal Kalecki, and incorporating insights from others including JK Galbraith and Hyman Minsky.

It is important to be aware of the differences in modelling approach when interpreting model results because the underlying assumptions can determine both the scale and direction of impacts (Mercure et al., 2019). A short summary of the theoretical differences is provided in Table 2.1 and described further in the text below.

The fundamental assumption of the neoclassical school is that 'agents' (individuals and companies) behave in a way that maximises the benefits to themselves. For example, companies will always aim to maximise their profits. This means that the agents in the model must be aware of both the options available to them and the consequences of these actions. Furthermore, markets are assumed to operate without frictions, with prices adjusting to the levels where demand and supply match (forming a general 'equilibrium'). Under these conditions, all available 'factors of production' (e.g. labour, capital) are used so that there is no (involuntary) unemployment and the level of production is determined by the supply of available factors of production.

Table 2.1 Key features of E3-India compared to a standard CGE model

	E3-India	*Standard CGE model*
Assumptions on behaviour	Estimated from past data	Assumed to be optimising, e.g. maximising profits
Assumptions on knowledge	All individuals and firms operate under conditions of uncertainty	Perfect knowledge is required so that individuals and firms can optimise decision-making
Treatment of prices and markets	Price sensitivity is estimated on historical data; markets may have frictions	It is assumed that markets operate without frictions and prices adjust to market-clearing rates
Treatment of money and the banking sector	The banking sector plays a key role in advancing credit and altering the money supply	The money supply is fixed and there is no role for the banking sector
How output is determined	Production levels are determined by the level of aggregate demand	Because all resources are used optimally, production levels are determined by available factors
Treatment of unemployment	Unemployed resources (including workers) exist when the level of aggregate demand is insufficient	Prices ensure that demand equals supply and therefore all unemployment is 'voluntary'

Source Developed by the author

The fundamental assumption of the post-Keynesian school is that agents do not possess the knowledge to make fully informed decisions about their actions (Keynes, 1921). They are therefore unable to optimise in their decisions. With limited information available, markets are also not able to operate in the fully flexible manner assumed by the neoclassical school. Under these conditions, there is no guarantee that all available factors of production will be employed; Keynes himself showed that agents will tend to save money to provide a safety net for the future, leading to unemployed workers elsewhere in the economy.

A key difference between the two schools of thought is an understanding of the nature of money (Lavoie, 2020). Under a neoclassical system, the money that is saved is automatically lent out to firms as loans (who spend it on investment, creating jobs). The post-Keynesian view understands that banks advance loans when they see profitable opportunities, with no automatic link between savings and investment (Keen, 2011). Crucially, recent studies have shown the post-Keynesian formation to be the correct one both anthropologically (Graeber, 2014) and in the present banking system (Werner, 2014, 2016). Pollitt and Mercure (2018) and Mercure et al. (2019) show how this difference in understanding can lead to opposite conclusions from model-based analysis.

The results from E3-India demonstrate these relationships through the model's 'financial block'. The financial block represents the flows of money between the institutional sectors in each state (i.e. the banking sector, households, businesses, government and external). In this way, it is possible to track the debts that are taken on by each sector. By considering both the stocks and the flows, it is possible to see if excessive debts are accumulating, which could be an indicator of potential future crisis.

The economic and financial specification of the model is especially important when discussing the impacts of Covid-19, which is an important aspect of the analysis in this book. Covid-19 caused both a demand and supply-side shock to the global economy in 2020. To accurately model the effects of Covid-19, a model that incorporates both demand and supply-side shocks is necessary. For example, CGE models that are based on neoclassical economics cannot adequately explain how household saving has increased at the same time that investment has dropped sharply. The need to rebuild consumer confidence in order to restart economic growth can be easily represented in E3-India, but is missing from the neoclassical models.

While the differences in underlying theory are complex and extremely interesting to economists, we must also remember that the state-level disaggregation provides a second clear distinction from other models that are available in India. As noted in the introduction to this chapter, there is a need for state-level analysis from policymakers who are operating at state level. However, the model can also give a similar state-level breakdown of results for policy that is set at national level. This helps policymakers to identify important distributional impacts and potentially design remedial policy. It is a core feature of the model.

2.4 Key Messages to Take Forward

The following chapters in this book will present several different sets of modelling results. A healthy degree of scepticism is required when interpreting model results and E3-India is no exception to this rule. The aim of the modelling exercise is not to provide estimates of impacts to the nearest decimal place, but to develop an understanding of what might happen in response to new policy, why it might happen and roughly how large the scale of the effect will be.

However, keeping this in mind, there are important insights that E3-India will bring to the policy debate. First, the model provides results close to the level of granularity required by policymakers; notably at the state level where most policymakers operate, but also providing results by sector and within different household income groups. Second, the model is based on a set of assumptions about how the real and financial economies work that are more consistent with the observed reality than that generally depicted in computer models. The results, which in some cases go against the general pattern of results from CGE models, can therefore also be considered more realistic.

Overall, the aim of modelling is to support policy development. There are many other aspects to policy analysis and we should not be overly reliant on models. The modelling results in this book are thus intended to inform policymakers and to provide reassurance that environmental policy will not lead to large-scale loss of jobs and incomes. Only then can we start to move forward with policies to avert environmental disaster.

Appendix I

Using the Model Further

The E3-India model is currently available to use for research purposes free of charge. After free registration, it may be downloaded from the model webpage: https://www.e3indiamodel.com/.

The model comes with a basic interface called the 'manager' that allows the user to design, run and assess scenarios. For example, it is possible to assess the effects of carbon taxes using the interface, without needing to understand any model code. The interface automatically generates line charts of time series, showing levels and differences from baseline. All numerical outputs can be exported to spreadsheet files.

Table 2.2 GDP

RGDP = RSC + RSK + RSG + RSX − RSM + RSS	
Definitions:	
RGDP	is GDP, m Rs at 2011 prices
RSC	is total consumer expenditure, m Rs at 2011 prices
RSK	is total investment (GFCF), m Rs at 2011 prices
RSG	is total final government expenditure, m Rs at 2011 prices
RSX	is total exports, m Rs at 2011 prices
RSM	is total imports, m Rs at 2011 prices
RSS	is total inventories, m Rs at 2011 prices

The model manual provides an introduction to the model interface and describes how to get started using the model. The website provides contact details for obtaining further support using the software.

Appendix II

As noted in the main text, E3-India consists of a combination of identity, accounting equations and behavioural equations in which elasticities are estimated using econometric techniques. This appendix covers the equations in both cases, giving the formal definitions as specified in the model's own variables. Each equation is defined at the regional level, i.e. for the 32 states and union territories and described in the appendix tables. Further information about each of the equations is provided in the model manual (Cambridge Econometrics, 2020).

Accounting Identities

Tables 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, and 2.8 show the key accounting relationships in the model.

The Econometric Equations

Tables 2.9, 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18, 2.19, 2.20, and 2.21 summarise the econometric behavioural equations in

Table 2.3 Output by product (demand side)

QR = QRY + QRC + QRK + QRG + QRX − QRM + QRR	
Definitions:	
QR	is a vector of output (by product), m Rs at 2011 prices
QRY	is a vector of intermediate goods, m Rs at 2011 prices
QRC	is a vector of final consumer output goods, m Rs at 2011 prices
QRK	is a vector of final investment goods, m Rs at 2011 prices
QRG	is a vector of final government goods, m Rs at 2011 prices
QRX	is a vector of final exported goods, m Rs at 2011 prices
QRM	is a vector of final imported goods, m Rs at 2011 prices
QRR	is a residual value to balance accounts, m Rs at 2011 prices

Table 2.4 Output by sector (supply is set to match demand)

YR = QR	
Definitions:	
YR	is a vector of output (by industry), m Rs at 2011 prices
QR	is a vector of output (by product), m Rs at 2011 prices

Table 2.5 Value added by sector

YRF = YR − YRQ − YRT	
Definitions:	
YRF	is a vector of value added, m Rs at 2011 prices
YR	is a vector of output (by industry), m Rs at 2011 prices
YRQ	is a vector of intermediate demands by industry, m Rs at 2011 prices
YRT	is a vector of taxes on products, m Rs at 2011 prices

Table 2.6 Consumer prices

PCR = (QCC ∗ PQRD ∗ CR) ∗ ((1 + CRTR)/ CR)	
Definitions:	
PCR	is a vector of consumer prices, by product, m Rs at 2011 prices
QCC	is a matrix that converts industry production to consumer products
PQRD	is a vector of prices of industry sales to the domestic market, m Rs at 2011 prices
CR	is a vector of consumer products, m Rs at 2011 prices
CRTR	is a vector of indirect tax rates on consumer products

Table 2.7 The consumer price index

PRSC = sum (PCR * CR)/RSC	
Definitions:	
PRSC	is the aggregate consumer price index, 2011 = 1.0
PCR	is a vector of consumer products' prices, 2011 = 1.0
CR	is a vector of expenditure on consumer products, m Rs at 2011 prices
RSC	is the sum of expenditure on consumer products, m Rs at 2011 prices

Table 2.8 Household real incomes

RRPD = (sum (YRW * YRE) + RRI)/ PRSC	
Definitions:	
RRPD	is a measure of real household income, m Rs at 2011 prices
YRW	is the average annual wage in each sector, th Rs
YRE	is the employment level in each sector, th people
RRI	is a measure of non-wage ('residual') income, m Rs
PRSC	is the aggregate consumer price index, 2011 = 1.0

Table 2.9 Aggregate energy demand by sector

FR0 = a + b1 * FRY + b2 * PREN + b3 * FRKE + e	
Definitions:	
FR0	is a matrix of total energy used by energy user, th toe
FRY	is a matrix of activity by energy user, m Rs at 2011 prices
PREN	is a matrix of average energy prices by energy user, Rs/toe
FRKE	is a matrix of technological progress by industry, converted to energy users
a	is the intercept from the econometric estimation
b1, b2, b3	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

E3-India. The tables provide a simplified representation of the error-correction model that is used. Further information about the functional form of the equations is provided in the model manual.

Table 2.10 Energy demand by fuel and sector (solid, liquid, gas and electricity)

$FRF = a + b1 * FR0 + b2 * PFRP + b3 * FRKE + e$

Definitions:

FRF	is a matrix of each fuel used by energy user, th toe
FR0	is a matrix of total energy used by energy user, th toe
PFRP	is a matrix of the fuel price relative to other energy prices
FRKE	is a matrix of technological progress by industry, converted to energy users
a	is the intercept from the econometric estimation
b1, b2, b3	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.11 Aggregate household spending

$RSC = a + b1 * RRPD + b2 * RRLR + b3 * RUNR + b4 * RPSC + e$

Definitions:

RSC	is a vector of total consumers' expenditure, m Rs at 2011 prices
RRPD	is a vector of total real household income, m Rs at 2011 prices
RRLR	is a matrix of long-run real interest rates
RUNR	is a vector of unemployment rates, measured as a percentage of the labour force
RPSC	is a vector of consumer price inflation, in percentage terms
a	is the intercept from the econometric estimation
b1, b2, b3, b4	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.12 Disaggregate household spending

$CR = a + b1 * RRPD + b2 * PRCR + b3 * RRLR + b4 * PRSC + e$

Definitions:

CR	is a matrix of consumers' expenditure by product, m Rs at 2011 prices
RRPD	is a vector of total real household income, m Rs at 2011 prices
PRCR	is a matrix of product prices, relative to aggregate prices
RRLR	is a matrix of long-run real interest rates
PRSC	is a vector of the consumer price index, 2011 = 1.0
a	is the intercept from the econometric estimation
b1, b2, b3, b4	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.13 Industrial investment

KR = a + b1 ∗ YR + b2 ∗ PKYR + b3 ∗ RRLR + e

Definitions:

KR	is a matrix of investment expenditure by industry, m Rs at 2011 prices
YR	is a matrix of gross industry output by industry, m Rs at 2011 prices
PKYR	is a matrix of investment prices relative to output prices by industry
RRLR	is a matrix of long-run real interest rates
a	is the intercept from the econometric estimation
b1, b2, b3	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.14 International exports

QRX = a + b1 ∗ QRDW + b2 ∗ PQRX + b3 ∗ YRKE + e

Definitions:

QRX	is a matrix of exports by industry, m Rs at 2011 prices
QRDW	is a matrix of production in the rest of the world, m Rs at 2011 prices
PQRX	is a matrix of export prices by industry, 2011 = 1.0
YRKE	is a matrix of technological progress by industry
a	is the intercept from the econometric estimation
b1, b2, b3	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.15 International imports

QRM = a + b1 ∗ QRDI + b2 ∗ PQRM + b3 ∗ YRKE + e

Definitions:

QRM	is a matrix of imports by industry, m Rs at 2011 prices
QRDI	is a matrix of domestic demand, m Rs at 2011 prices
PQRM	is a matrix of import prices by industry, 2011 = 1.0
YRKE	is a matrix of technological progress by industry
a	is the intercept from the econometric estimation
b1, b2, b3	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.16 Export prices

$PQRX = a + b1 * PQWE + b2 * YRULT + e$

Definitions:

PQRX	is a matrix of export prices by industry, 2011 = 1.0
PQWE	is a matrix of prices in the rest of the world, 2011 = 1.0
YRULT	is a matrix of unit production costs by industry (excl materials)
a	is the intercept from the econometric estimation
b1, b2	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.17 Import prices

$PQRM = a + b1 * PQWE + b2 * YRULT + e$

Definitions:

PQRM	is a matrix of import prices by industry, 2011 = 1.0
PQWE	is a matrix of prices in the rest of the world, 2011 = 1.0
YRULT	is a matrix of unit production costs by industry (excl materials)
a	is the intercept from the econometric estimation
b1, b2	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.18 Domestic industry prices

$PYH = a + b1 * YRUC + b2 * PQRM + b3 * YRKE + e$

Definitions:

PYH	is a matrix of industry production prices, 2011 = 1.0
YRUC	is a matrix of unit production costs by industry
PQRM	is a matrix of import prices by industry, 2011 = 1.0
YRKE	is a matrix of technological progress by industry
a	is the intercept from the econometric estimation
b1, b2, b3	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.19 Employment by sector

$YRE = a + b1 * YR + b2 * LYLC + e$

Definitions:

YRE	is a matrix of total employment by industry, in thousands of persons
YR	is a matrix of gross output by industry, m Rs at 2011 prices
LYLC	is a matrix of real labour costs per worker, m Rs at 2011 prices
a	is the intercept from the econometric estimation
b1, b2	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.20 Wage rates by sector

$YRW = a + b1 * YRWE + b2 * PRSC + b3 * LYRP + b4 * RUNR + e$

Definitions:

YRW	is a matrix of nominal average earnings by industry, Rs per person-year
YRWE	is a matrix of nominal average earnings in other sectors, Rs at current prices
PRSC	is a vector of the consumer price deflator, 2011 = 1.0
LYRP	is a matrix of labour productivity (output per worker)
RUNR	is a vector of the standardised unemployment rate
a	is the intercept from the econometric estimation
b1, b2, b3, b4	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

Table 2.21 Labour market participation rates

LRP = a + b1 ∗ RSQ + b2 ∗ RYWS + b3 ∗ RUNR + e	
Definitions:	
LRP	is a matrix of labour force participation rates by gender and age group
RSQ	is a vector of total gross industry output, m Rs at 2011 prices
RYWS	is a vector of average wage rates, m Rs at current prices
RUNR	is a vector of the standardised unemployment rate
a	is the intercept from the econometric estimation
b1, b2, b3	are estimated elasticities from the econometric estimation
e	is the error term from the econometric estimation

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CHAPTER 3

Data Construction and Sources: E3-India Model

Kakali Mukhopadhyay and Unnada Chewpreecha

3.1 Introduction

As a macro-econometric model, E3-India data composition is very extensive. E3-India model consists of three separate modules: Economy, Energy and Emissions, as comprehensively explained in Chapter 2. The economic activity and general price levels from economy modules determine demand for energy which in turn generates emission. Feedbacks between modules include adjustment to energy sector input-output coefficients, energy price level including effects from policies and power sector

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investment. In Table 3.2 in the Appendix, the detailed description of data construction that was undertaken for each of these modules is provided.

The model comprises data for the time period 1993–2016 for 32 States and Union Territories with 38 sectoral classifications. E3-India's 38 sectoral aggregation is based on the classifications as provided by the National Industrial Classification (NIC) Codes by the Ministry of Statistics and Programme Implementation, Government of India. Based on the ten parameters mentioned in Table 3.2, the 38 sectors constitute manufacturing sectors (17), Service sectors (12), Agriculture (1), Forestry (1), Mining sectors (3), Utilities (3) and Construction (1). These are shown in Table 3.3 in Appendix.

3.2 Data Construction for the Economy Module

The economy module captures the inter-industry transactions and the consequent impact on various monetary variables. Given below are the aggregate economic variables through which changes in demand levels influencing the economic activity in the economy module are determined and the sources of data collection for the respective variables.

The variables mentioned above are used in E3-India model according to the System of National Accounting (SNA) to ensure accounting consistencies between these variables. Image 3.1 provides an overview of the E3-India structure.

Since E3-India is a demand-driven model, the economic interdependence between sectors is measured by how increase in one sector's output affects the increase in input levels from its suppliers. The model constitutes the input-output tables for, 2003–2004 and 2011–2012. In this study, I-O tables at the state level were constructed for which 138 sectors of 2011–12 I-O table were aggregated into 38 sectors based on 10 parameters provided by the National Accounts. These are Total Value of Output, Fuel Consumed, Material Consumed, Total Inputs, Gross Value Added, Gross Fixed Capital Formation (GFCF), Change in Stock, Profits (Operating Surplus), Employment and Compensation to Employees. Based on the demand-supply interactions as shown in Image 3.2, E3-India model provides three loops or circuits arising from economic interdependence arising from changes in final demand levels. The three loops are investment (Type I multiplier), income (Type II multiplier) and trade. In order to formulate these three loops, the data construction that was undertaken is explained below.

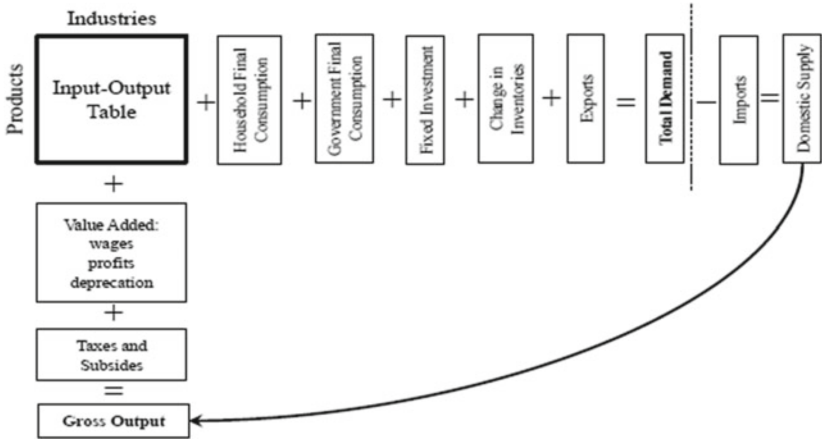

Image 3.1 Determination of supply and demand in E3-India model (*Source* E3-India manual)

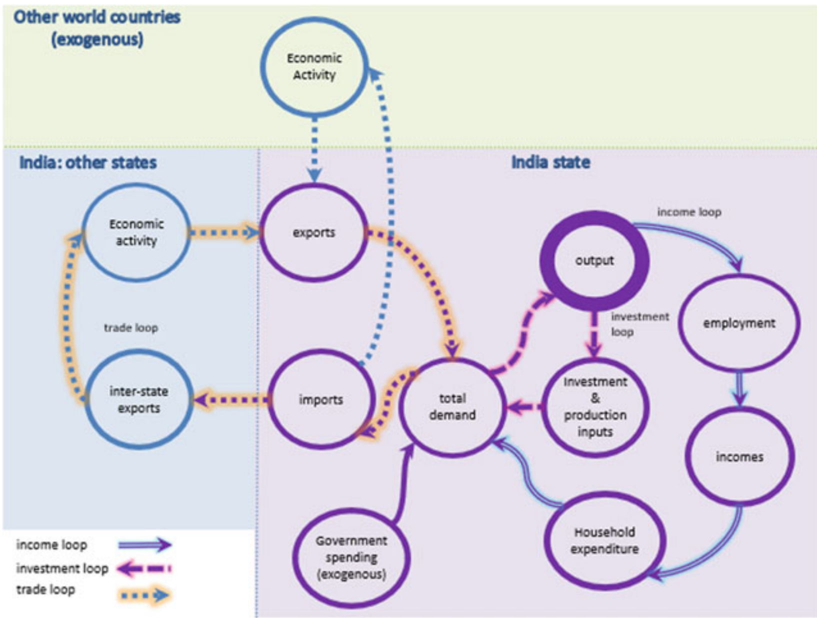

Image 3.2 E3-India basic economic structure (*Source* E3-India manual)

i. Investment Loop (Type I multiplier)

The increase in demand (and expected increase in future) will lead to increase in sectoral output as a result of which there is increase in investment demand in the sector and increase in intermediate demand across their supply chain, which is accounted by the investment loop. For determining the investment demand, the Gross Fixed Capital Formation (GFCF) is used which was collected from the National Accounts Statistics report. The ratio of GFCF to National GVA for each sector was calculated and the ratio was multiplied with the state data of sectoral GVA. However, due to data limitations, investment is not disaggregated by asset in E3-India model. Stock building is treated as exogenous in the model.

ii. Income Loop (Type II multiplier)

The increase in sectoral output also leads to increase in employment demand, leading to a higher level of income and additional consumer expenditure. This is called as the Type II multiplier. For this purpose, the sources of income and consumption expenditure pattern had to be determined. However, in India, data on income levels and its sources are not collected, hence it is estimated using the consumer spending pattern itself which was constructed by developing a linkage with the Indian Human Development Survey (IHDS).

The NSSO Level and Pattern of Consumption Expenditure-2012 contains information about expenditure pattern of 346 food and non-food items for urban and rural region. The items were categorised into 13 E3-India consumer spending categories. According to the NSSO reports on Level and Pattern of consumption expenditure (various issues), the observations documented on expenditure pattern for 346 food and non-food items for urban and rural regions were ranked into 12 fractile classes. However, the report does not reveal the sources of income or the occupation of the household head. Since a direct link couldn't be established between NSSO consumption expenditure pattern and sources of income, the National Classification of Occupation (NCO)-2004, Government of India was collated and linked with the IHDS household survey report which is an extensive pan-India household survey, covering range of variables including occupation, demographic characteristics, education etc.

The IHDS Household Survey was first linked to NCO which was then linked to NSSO consumption expenditure data.

The rural and urban population were classified into different classes each, according to Monthly Per Capita Expenditure (MPCE) in India collected from NSSO and MOSPI surveys (various issues) rural-urban classification was based on percentage terms of MPCE.

As per the description provided in the NCO Code document, each of the IHDS occupation was categorised in one of the NCO Code irrespective of urban or rural region. For each NCO codes (occupation), percentage of people deriving their income from the list as enumerated by IHDS was estimated.

Of the total 12 new fractile classes prepared, code "x" is for unclassified occupation which forms the lowest income group and consequently also the lowest on consumption expenditure rankings. Hence, 0–10% MPCE class (lowest MPCE) from the NSSO report on "Level and Pattern of Consumption Expenditure of India has been assigned to this group. Similarly, code 1 (Legislators, Senior officials and Managers) forms the 90–100 percentile, the highest fractile class. Thus, it implies higher the NCO Code lower the fractile class they are grouped into.

iii. Trade Loop

The increase in domestic demand levels also leads to increase in demand for imported goods and services (within and outside India) leading to higher production levels in other states as well which is measured by the trade loop. The economic activities outside India are treated as exogenous to the model.

Trade statistics for the respective states were collected from the Directorate General of Commercial Intelligence and Statistics (DGCIS), Government of India. For Inter-regional trade, inland (rail, road and river) and coastal trade (ports) data were provided for 177 sectors across 32 regions which was aggregated into 38 sectors as mentioned above in Section 3.1. Since the data were collected in physical units, it was converted into monetary units using individual sector price indices. Export prices for ports have been taken as proxy for the interstate price data.

3.3 Data Construction for the Energy Module and Environment (Emission) Module

The economy module provides the measures of economic activity and general price levels to the energy module. The energy module is constructed for each 21-energy user disaggregated by 5 energy carrier for each state. Furthermore, power sector in E3-India contains 24 different power generation technologies (see Table 3.4 in Appendix).

i. Fuel demand by different energy users

Fuel demand in E3-India is in physical unit (thousand tonnes of oil equivalent). For the power sector, fuel demand data is obtained from MOSPI Installed capacity, generation and consumption reports. Detailed industry use of fuels come from data obtained from ASI manufacturing fuel use. For residential and services sector use of energy, state-level consumption is available for electricity (MOSPI Electricity sold to ultimate consumer reports). Non-electricity demand from residential and services sector was estimated from national data using shares of state consumer spending and services GVA as a guide.

ii. Power generation data

Power generation and capacity by 24 different technologies were constructed from State-wise installed capacity of grid-interactive renewable power and installed capacity, generation and consumption report from MOSPI. Other power sector information such as levelized cost of different technologies was based on national figures obtained from the IEA publications.

iii. Energy price data

State-level energy prices for each fuel are not available. Instead, energy prices for each state are assumed to match the national Indian prices obtained from the IEA Energy Statistics which provide prices (before and after taxes) in USD per tonne of oil equivalent by country and by fuel. Global fossil fuel price data for oil, coal and gas also comes from the IEA.

iv. CO_2 emissions in E3-India

Time-series data for CO_2 emissions, disaggregated by energy user, are calculated using national emission coefficients obtained from the IEA.

The energy demand by fuel, fuel users and states are constructed. This creates energy module where the aggregated energy demand is primarily determined by:

i. Economic activity in each of the energy users.
ii. Average energy prices for each energy user in real terms.
iii. Technological variables, represented by investment and R&D expenditure.

Image 3.3 represents the interlinkages between the economy and energy module with its subsequent impact on the environment (represented in

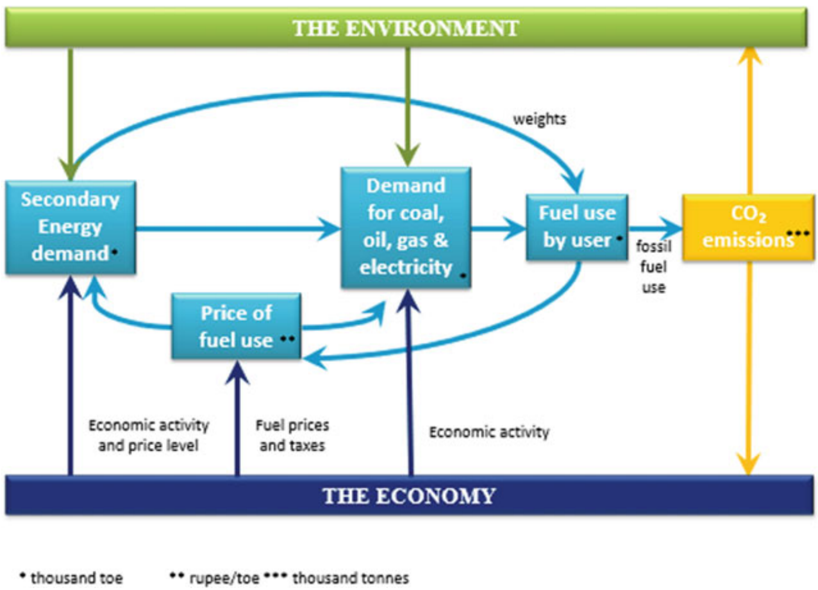

Image 3.3 Overview of the energy and environment modules in E3-India (*Source* E3-India manual)

E3-India as CO_2 emissions). On the bottom left-hand side of the figure, we see how the energy demand is determined by the economic activity as well as changes in price levels. The consumption from various energy sources as well as changes in price levels is estimated based on the time series data for various energy sources collected as shown in Table 3.1 and the data for energy prices collected from IEA. Through the feedback loop, the transactions are recorded simultaneously in energy and economy modules, but in different units. An industry energy user's purchases of energy product are a function of economic activity of the energy user, energy price and cumulative investment by the user (proxy for technology). This gives energy demand measured in tonnes of oil equivalent (toe). The feedback from energy to economy module is through an input-output adjustment of the sector purchasing inputs from energy supplier or energy extraction sector or directly through household expenditure on fuel for residential user. By multiplying energy demand with energy price, we can obtain feedbacks in millions of rupees (see Image 3.4).

Table 3.1 E3-India data sources for energy variables

Sr. no.	*Variable*	*Source*
1.	Coal consumption	MOSPI Installed capacity, generation and consumption (various issues), ASI manufacturing fuel use
2.	Oil consumption	Indian Petroleum and Natural Gas statistics (Ministry of Petroleum & Natural Gas), ASI manufacturing fuel use
3.	Gas consumption	MOSPI Installed capacity, generation and consumption reports (various issues), ASI manufacturing fuel use
4.	Electricity consumption	MOSPI Electricity sold to ultimate consumer reports (various issues), ASI manufacturing fuel use
5.	Biomass Consumption	MOSPI renewable generation capacity data, ASI manufacturing fuel use
6.	Energy Prices	International Energy Agency Energy prices and taxes (national level)
7.	Power generation	MOSPI Installed capacity, generation and consumption (various issues)

Source Compiled from various sources

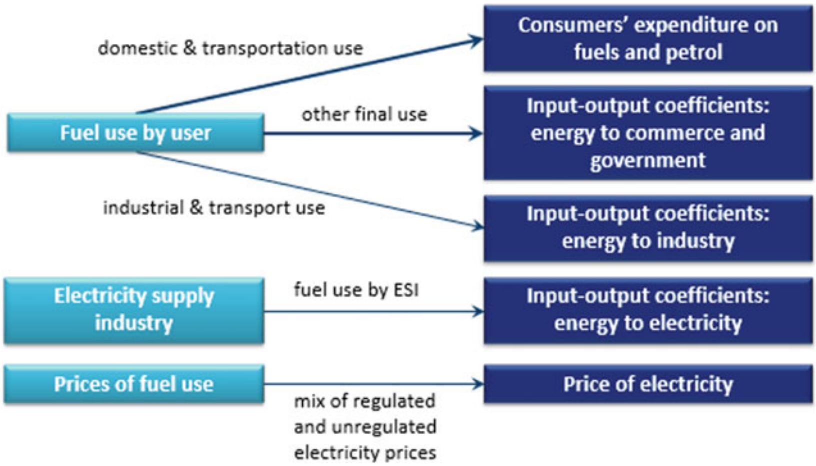

Image 3.4 Feedbacks from energy module to economy module in E3-India (*Source* E3-India manual)

3.4 Limitations of E3-India Data

Since E3-India is an econometrics model, full set of timeseries data are required for econometrics estimation. After raw data were processed and mapped to the E3-India model classification, gaps in data were then filled. This process of filling in data gaps uses a computer programme to estimate growth rates and shares while constrained detailed sectors to adding up to aggregate level.

The most straightforward example of this is when the growth rates of a variable are known and so the level can be estimated from these growth rates, as long as the initial level is known. Sharing is also used when the time-series data of an aggregation of sectors are available but the individual time series is not. In this case, the sectoral time series can be calculated by sharing the total, using either actual or estimated shares.

Extrapolation and interpolation techniques were also used to fill gaps in the timeseries. Extrapolation is often used in the case where aggregate data are available but sectoral data are not. A special procedure has been put in place to estimate the growth in more disaggregated sectors so that the sum of these matches the known total, while the individual sectoral growth follows the characteristics of each sector. Interpolation is used when no external source is available, to estimate the path of change during an interval, at the beginning and end of which data are available.

Appendix A

See Tables 3.2, 3.3, and 3.4.

Table 3.2 E3-India data sources for economic variables

Sr. no.	Variable	Source(s)
1.	Population	MOSPI Net State Domestic Product Series Census of India—For state wise Rural and urban Population
2.	Unemployment and Labour participation rates	NSSO Employment and Unemployment Situation in India surveys, NSSO Household expenditure and Employment Situation in India Surveys
3.	Economic Sectors based on National Accounts (ten parameters)	Agriculture—State-wise And Item-wise Estimates of Value of Output from Agriculture and Allied Sectors, Central Statistics Office, MOSPI, Central Statistical Office, Government of India for various years Forestry—Forest Cover in States and UT in India Compendium of Environment Statistics for years (various issues) Mining: Indian Mineral Year Book (various issues), Indian Bureau of Mines, Government of India Manufacturing: Annual Survey of Industries Data (various issues) Services—Economic Characteristics of Unincorporated Non-Agricultural Enterprises in India, NSSO, CSO and MOSPI reports (various issues) Construction—EPWRF dataset (various issues)

(continued)

Table 3.2 (continued)

		Utilities—Financial Aspect of Major and medium Irrigation Projects, (Central Water Commission), State-wise consumption of major petroleum products, (Indian Petroleum and Natural Gas Statistics, GOI), State Power Utilities and Electricity Depts. Annual Reports various issues
4.	Consumer Spending	NSSO Household Consumer Expenditure and Employment situation NSSO Key Indicators of Household Consumer Expenditure in India NSSO Level and Pattern of Consumer Expenditure in India (various issues) NSSO Household Consumption of Various Goods and Services in India reports
5.	Government Spending	Reserve Bank of India State Finances: A study of Budgets Indian Ministry of Finance Union Budgets (various issues) Own estimates for E3-India Population using information from national total
6.	Total Gross Disposable Income	Calculated from Government dataset (National and regional level)
7.	Trade	Directorate General of Commercial Intelligence and Statistics (DGCIS), Government of India

Note MOSPI—Ministry of Statistics and Programme Implementation; NSSO—Indian National Sample Survey Reports; CSO—Central Statistical Office
Source Compiled from various sources

Table 3.3 E3-India sectoral aggregation

Sr. no.	*Sector-wise broad categories*	*Sectors categorized by MOSPI*	*E3-India sectors*
1.	Agriculture (1)	Paddy, Wheat, Coarse cereals, Gram, Arhar, Other Pulses, Groundnut, Rapeseed and mustard, Other oil seeds, kapas, jute, hemp and mesta, sugarcane, coconut, tobacco, tea, coffee, fruits, vegetables, other food crops, milk, wool, egg and poultry, other livestock products, inland fish, marine fish	Agriculture etc.
2.	Forestry (1)	Other forestry products	Forestry
3.	Mining (3)	Crude petroleum, natural gas	Oil & Gas
		Coal and Lignite	Coal
		Iron ore, Manganese ore, Bauxite, Copper ore, Other metallic minerals	Other Mining
4.	Manufacturing Sector (17)	Industry wood, Firewood, wood and wood products except furniture, furniture and fixtures	Wood & Wood Products
		Processed poultry meat & poultry meat products, processed other meat & meat products, Processed fish & fish products, Processed fruits & vegetables, dairy products, edible oils and fats, grain mill products, starch and starch products, sugar, bread & Bakery products, miscellaneous food products, alcoholic beverages, non-alcoholic beverages, tea processed, coffee processed, tobacco products	Food, Drink & Tobacco
		Cotton yarn and textiles, synthetic yarn and textiles, wool yarn and textiles, silk yarn and textiles, carpet weaving, ready-made garments, misc. textile products	Textiles & Clothing
		Leather footwear, Leather and leather products except footwear	Leather & Leather Products

(continued)

Table 3.3 (continued)

Sr. no.	*Sector-wise broad categories*	*Sectors categorized by MOSPI*	*E3-India sectors*
		Rubber, Rubber products, plastic products	Rubber & Plastics
		Paper, paper products and newsprint, publishing, printing and allied activities	Paper, Printing & Publishing
		Drugs and Medicine	Pharmaceuticals
		Petroleum products, Coal tar products	Manufacturing Fuels
		Inorganic and organic chemicals, fertilizers, pesticides, paints, varnishes and lacquers, synthetic fibres, resin, other chemical and chemical products	Chemicals. (organic + inorganic)
		Electronic equipment including T.V, medical precision, optical instrument, communication equipment watches and clocks	Electronics
		Electrical industrial machinery, electrical cables, wires, batteries, electrical appliances, other electrical machinery	Electrical Engineering & Instrument
		Limestone, Mica, Cement, Other non-metallic minerals	Non-Met. Min. Prods.
		Iron and Steel ferro alloys, Iron and steel casting and forging, Iron and steel foundries, non-ferrous basic metals (including alloys)	Basic Metals
		Miscellaneous metal products	Metal Goods
		Motor vehicles, Repair and maintenance of motor vehicles	Motor Vehicles
		Ships and boats, Rail equipment, motor cycles and scooters, bicycles, cycle-rickshaw aircrafts and spacecrafts, other transport equipment, supporting and auxiliary transport activities	Other transport equipment

(continued)

Table 3.3 (continued)

Sr. no.	*Sector-wise broad categories*	*Sectors categorized by MOSPI*	*E3-India sectors*
		Miscellaneous manufacturing, hand tools, hardware, tractors and other agricultural implements, industrial machinery for food and textile industry, industrial machinery (except food and textile), machine tools, other non-electrical machinery, Gems and jewellery, storage and warehousing	Other manufacturing
5.	Services (12)	Trade	Trade and Logistics
		Hotels and Restaurants	Hotels & Catering
		Land transport	Land transport
		Water transport	Water Transport
		Air transport	Air transport
		Communication services	Communications
		Financial services, insurance services	Banking, Finance & Insurance
		Real estate services, computer-related services, Legal services, other business services	Other Business Services
		Education services, R&D services	Education
		Human health and social care services	Health & Social Work
		Public administration & defence	Public Admin & Defence
		Recreation, entertainment and radio & TV broadcasting and other services, Community, social and personal services, Renting of machinery and equipment, ownership of dwellings	Misc. Services
6.	Construction	Construction and construction services	Construction
7.	Utilities (3)	Electricity	Electricity Supply
		Gas	Gas Supply
		Water supply	Water Supply

Source Developed by authors

Table 3.4 E3-India energy classifications

Sr.no	*Fuel users*	*Fuels*	*Power technologies*
1.	Power own use & trans.	Coal	Nuclear
2.	Other energy own use & transformation	Oil	Oil
3.	Basic metal	Natural Gas	Coal
4.	Metal goods	Electricity	Coal + CCS
5.	Chemicals	Biomass	IGCC
6.	Non-metallic minerals		IGCC + CCS
7.	Food, drinks & tobacco		CCGT
8.	Textile, leather & clothing		CCGT + CCS
9.	Rubber and plastics		Solid Biomass
10.	Paper & publishing		S Biomass CCS
11.	Engineering etc.		BIGCC
12.	Other industry		BIGCC + CCS
13.	Construction		Biogas
14.	Rail transport		Biogas + CCS
15.	Road transport		Tidal
16.	Air transport		Large Hydro
17.	Water transport		Onshore
18.	Households		Offshore
19.	Services		Solar PV
20.	Agriculture & fishing		CSP
21.	Non-energy use		Geothermal
22.			Wave
23.			Fuel Cells
24.			CHP

CHAPTER 4

Application of E3-India Model in Agriculture and Food Processing Sector

Paul J. Thomassin and Kakali Mukhopadhyay

4.1 Introduction

From its initial goal of making the country self-sufficient in food grains to making it a leading producer of various agricultural products, the agricultural sector has been the central pillar of the Indian economy since the very beginning. However, despite its prowess, the Indian agricultural sector has traversed a rather rough path in the recent past decades. With the structural transformation underway, the share of the agricultural sector in the nation's GDP has been declining consistently. The

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sector's share in GDP has declined from around 45% in 1951 to almost 16% in 2011 (NITI Aayog, 2014). Conversely, the incommensurate shift in the labour force from the agricultural sector to the industrial and services sectors, coupled with the inevitable distributional consequences of the structural transformation itself, have had serious implications for the growth and sustainability of the sector.

Although the share of agriculture and allied sectors in the nation's GDP halved two decades ago from what it was in 1955, the sector continues to be the largest source of livelihood in the country, employing over half of the total workforce. The share of agricultural workers in the total workforce stood at 69.7 and 54.6% in 1951 and 2011, respectively (GOI, 2018a). What makes the matter even more worrisome is the fact that even with abundant land and workforce at its disposal, India's agricultural productivity remains critically low, as compared to other top producing countries such as China, Brazil, and the United States (Deshpande, 2017). China, for instance, produces higher agricultural output despite its area under cultivation and fertiliser consumption being lower than India.

In terms of agricultural trade, India has consistently remained a net exporter of agri-products since 1991. However, after recording a more than ten-fold increase in trade surplus between 1991–1992 and 2013–2014, rising imports and declining exports between 2013–2014 and 2016–2017 resulted in a 70% decline in the trade surplus (Jain, 2017). While global factors did have a role to play in the plummeting export earnings, the situation was exacerbated by infrastructure inadequacy and restrictive domestic policies such as price distortions. India's farm policy currently possesses an inherent consumer bias, whereby export restrictions are imposed on important food items to prevent inflationary pressures in the domestic economy. The policy deprives farmers of higher prices in the international market and also adds an element of income uncertainty, thereby hampering farmers' incentive to cultivate exportable crops (Gulati & Saini, 2017).

Another major paradox concerning Indian agriculture is the fact that despite declaring food-sufficiency as its goal and eventually becoming a net exporter of food grains, India has the largest undernourished population in the world. 20% of children under 5 are underweight while 34.7% of them are stunted (India FoodBanking Network, 2020). India ranked 102 of 117 countries behind its neighbours Nepal, Pakistan, and Bangladesh on the Global Hunger Index (2019). Although certain states like Haryana, Punjab, Uttar Pradesh, and Maharashtra do experience surplus production, infrastructure inadequacies in terms of storage and transportation result in huge harvest and post-harvest losses. Annually, close to 21 million metric tonnes of wheat rots in India; a figure that is equal to Australia's total annual production (Goswami, 2018). This food wastage however, isn't limited to one level alone but perforates through every stage; from harvesting, processing, packaging, and transporting to the end stage of consumption, arising mainly from gaps in the logistics supply-chain (Felder, 2019). Therefore, translating food sufficiency into food security would require a paradigm shift in the agricultural policies, gearing them away from simply increasing the volume of output towards addressing more critical issues related to infrastructure and productivity.

Access to better technology and credit, investments in irrigation and relative price incentives have been instrumental in the past in catapulting the country's farm sector to an important economic position both domestically and globally (Gulati & Saini, 2017). With 82% of farmers being small and marginal, access to credit and investment in irrigation continue to be critical even today (FAO, 2020). Although institutional credit sources have become the preferred source for availing credit, a significant portion, i.e. approximately 30% of agricultural households still avail credit from non-institutional sources only which is a cause of concern (RBI, 2019). A 2010 study found that the probability of taking credit from institutional sources increases significantly with farm-size and education level of the farmer. More importantly, the results have reconfirmed the vulnerability of weaker sections, i.e. households belonging to scheduled castes, scheduled tribes, and other backward castes, in getting credit from the institutional sources (Kumar et al., 2010). Strengthening the institutional credit mechanism and improving the reach of the same, especially to the weaker section of the farming community, is a precursor to improving the performance of the agricultural sector.

Concerns remain in the sphere of irrigation as well. The agriculture sector alone consumes more than 90% of the total groundwater draft in irrigation. While groundwater offers the advantage of independent access and timely availability, the huge dependency on groundwater has led to the depletion of water tables in 64% of the districts in the country between 2002 and 2016 (Jain et al., 2019). Government efforts have been initiated to intensify the outreach of water efficient micro-irrigation techniques under the Pradhan Mantri Krishi Sinchayee Yojna (PMKSY). However, the parliamentary standing committee on rural development has revealed that only 10% of the projects taken up under the watershed development component of the PMKSY have been completed (The Wire, 2018). Ensuring accessibility through institutional support systems is necessary for successful adoption of water efficient technologies as the majority of the sown area in India still remain rain fed.

The Economic Survey 2017–2018 stressed the need to enhance the level of farm mechanisation in the country for enhancing agriculture productivity, increasing agriculture exports, mitigating labour shortage, and facilitating judicious use of scarce natural resources and farm inputs (ETMarkets.com, 2018). Currently, the farm mechanisation level in India ranges from 40–45%, as compared to 90% in developed economies. India's farm equipment market is 7% of the global market, with more than 80% of the value contribution coming from tractors (PWC-FICCI 2019). To address this issue, an ambitious target of increasing the availability of farm power from 2.02 kW/ha (2016–2017) to 4.0 kW/ha by the end of 2030 has been set (NABARD, 2018b).

Realising the strategic importance of the agricultural sector in propelling India's economic as well as social development, the policy focus has shifted from simply achieving output targets to generating higher and stable income for the farming population. This is reflected in the Government's intention to double farmers' income by 2022 (GOI, 2019). The revised income approach is centred on higher profits from farming through reduced cost of cultivation, higher productivity and better price realisation by farmers. Similarly, the focus for agricultural exports has expanded from solely diversifying the export basket to establishing a stable trade policy regime to rule out volatility which has far-reaching impacts on farmers' incomes as well as their ability to take credit. This vision is spelled out in the Agriculture Export Policy, 2018 (GOI, 2018b).

An important sector that can significantly contribute towards the ambitious targets outlined in both these policies in terms of greater value addition, improving exports, and creating alternative employment opportunities is the Food Processing Industry (FPI)(RBI, 2020). This sector links the primary sector with the secondary sector and therefore creates important forward linkages for the former (Nagaich & Priyani, 2019). So far, the transfer of surplus labour from agriculture to manufacturing remains limited (Binswanger-Mkhize, 2013). A strong processing base can therefore serve as the much-needed avenue to accelerate India's structural transformation. Although India's FPI is at a nascent stage at present, the opportunities available to the sector are immense. With the increased importance of processed food in the consumer basket, the implementation of quality standards has been a major barrier for the Indian FPI, however policy initiatives for strengthening quality standards can provide the essential impetus to the sector (RBI, 2020). Promoting the adoption of technology and digital solutions at every stage of the industry's supply chain can be a major step in addressing the logistical challenges that the sector faces. Similar to the agricultural sector, easy availability of credit is critical for the industry to be able to invest in necessary infrastructure.

Thus the importance of policy support for shaping the future of both these sectors is immense and the ongoing COVID-19 pandemic, which has affected all elements of the food system, from primary supply, to processing, to trade as well as national and international logistics systems, has only accentuated the need for more comprehensive policy reforms (Schmidhuber et al., 2020). In this chapter we undertake a regional analysis of national and sub-national level policies concerning the agricultural and food processing sector. For this we employ the regional framework of the E3-India model which has been described extensively in Chapter 2. Policy analysis at the regional level can help in identifying the strengths and weaknesses of various states in terms of employment, output, and exports, along with evaluating the environmental feasibility of policies at the regional level. By leveraging their unique strengths and addressing their weaknesses through additional stimulus at the regional level, Indian states can ensure the overall sustainability of Agriculture and its allied services as well as the FPI. Such an analysis becomes even more relevant in the wake of the current pandemic which has inflicted varying degree of impact across different states. By identifying the areas that are most crucial for revival, the states can ensure that their respective agriculture and food processing sectors exit the crisis in the most resilient manner possible.

The rest of the chapter is structured in the following manner: Sect. 4.2 reviews the literature, Sect. 4.3–4.5 elaborate upon the policy impact analysis where Sect. 4.3 reviews two National level scenarios, Sect. 4.4 reviews two Regional level scenarios and Sect. 4.5 analyses two scenarios related to the COVID-19 pandemic. Finally, the conclusions are given in Sect. 4.6.

4.2 Literature Review

Indian agricultural is one of the most extensively researched areas of study. The multitude of issues in and around the sector has attracted a lot of academic attention. While some of these studies have undertaken an overall evaluation of the sector to identify the bottlenecks, other studies have focused on an in-depth analysis of a particular issue being faced by the sector. There are quite a few studies that have analysed the impact of the 1991 economic reforms on the agriculture sector. These include Rao and Gulati (1994) who identified the supply side area for policy reforms that would enable the sector to exploit the opportunity of trade liberalisation, Gulati and Saini (2017) who analysed major agricultural reforms in the country beginning with the impact of the 1991 reforms on the agricultural sector followed by policy reforms in subsequent years, especially on fertiliser-price policy and agricultural trade. Storm (1997) provided a quantitative assessment of the agricultural trade reform policy using a computable general equilibrium model. Storm (2003) discusses the transition problems in policy reform in the context of agricultural trade liberalisation in India. Bhalla and Singh (2009) study the performance of agriculture at the state level in India during the post-reform period (from 1990–1993 to 2003–2006) and the immediate pre-reform period (from 1980–1983 to 1990–1993).

Gulati and Saini (2017) present a comprehensive report on commodity wise analysis of government policies and restrictions that lead to price distortions in Indian agriculture and the resulting impact on the farming community. The study also outlines India's domestic agricultural policies as well as its agricultural trade policies. Gadgil (1986) presents one of the earliest reviews of the policies related to agricultural credit in India. The paper reviews major changes in the farm credit policy from 1951 to 1983 and the impact of these reforms on the strength of credit institutions and their viability. Hoda and Terway (2015) provide an extension to the previous study by reviewing the credit policy for agriculture in India for the period 1951–2013. The study sheds light on the effectiveness of instruments like Special Agricultural Credit Plan, Kisan Credit Cards, and Financial Inclusion Programmes introduced through newer policy reforms in the area. Similarly, Jain et al. (2019) explore the area of irrigation reforms. The study reviews irrigation schemes and the impact of government initiatives on micro-irrigation. Ghosh (2011) examines the impact of agricultural policy reforms on spatial integration of food grain markets in India. Furthermore, scholars have also undertaken sub-national studies to explore the prospects of the agricultural sector of the respective states. However, policy impact studies remain limited, mainly confined to the states of Punjab and Haryana. Alary and Deybe (2005) analysed the impacts of different water tariff reforms on rural livelihood and water and public resource in Haryana. Azhar and Nabi (2011) undertook an impact assessment of Punjab irrigation sector reforms interventions. Singh (2012) analysed the institutional and policy aspects of Punjab agriculture.

As compared to the agriculture sector, research on the Indian food processing sector remains limited, with more studies focusing on the overall prospects of the sector and fewer on any form of policy impact evaluation. Ali and Singh (2009) explored the determinants of efficiency and productivity changes in the Indian FPI, followed by policy implications. Singh et. al. (2012) highlighted the challenges and opportunities in the FPI in India. Dharni and Sharma (2015) explored the status of supply chain management in food processing sector in India.

With the impact of the current pandemic becoming more visible, the number of studies highlighting the implications of the pandemic on agriculture and food processing sectors of the country is also increasing. Arumugam et. al. (2020) analyse the impact of COVID-19 on the agricultural sector of India. Rawal and Verma (2020) evaluate the agricultural supply chains during the COVID-19 lockdown. Siddiquei and Khan (2020) highlight the challenges for vegetable production in India. Gupta and Mohanta (2020) evaluate the impact of COVID-19 on sugarcane growers and sugar industry.

Our chapter adds to the existing literature on the Indian agriculture and FPI by providing quantitative evidence to support the feasibility analysis of both national and sub-national policies at a regional level. It is also the pioneering work in the field of agriculture and food processing using the E3-India model. The E3-India model proves to be an inevitable policy tool in understanding the implications of these policies because of its ability to address regional variation and capture region-specific implications, thereby facilitating evidence-based policymaking at the regional level. The model enables us to assess the macroeconomic impact of policies through variables like GDP, Income, Output, Employment, etc. At the same time, it allows us to evaluate the environmental feasibility of these policies through impact variables like Electricity Use, Emissions of CO_2, etc.

4.3 National Scenarios

1. Food Processing Industry

The first scenario relates to India's sunrise sector, the FPI. The FPI promotes vital linkages and synergies between the two pillars of the economy, i.e. agriculture and industry, which makes this industry enormously significant. In comparison to other sectors, the food processing sector accounted for 7.9% of manufacturing GVA and 9.5% in agricultural value-added in 2017–2018.[1] It is also a major employment provider, accounting for a share of 11.6% in total employment (Invest India, 2020). It has been identified as one of the key thrust areas under the 'Make in India' Programme because of its potential in terms of value addition to farm output, employment opportunities, exports potential and strengthening of the domestic supply chain.

According to the Annual Survey of Industries 2016–2017, the food processing sector in India was ranked 1st in terms of total number of factories (15.95%), operational factories (16.78%), workforce (11.36%), and total output (14.09%) (Bhatia et. al., 2020). With revised policy norms allowing up to 100% FDI in the sector, changing consumption patterns and urbanisation, the FPI is bound to grow on a large scale in the coming years. Looking at its potential, the CII, (2019) has claimed that the FPI has the capacity to enhance its production capacity up to USD 535,000 million by 2026. As of 2018, the All India level output of the industry was USD 175,751 million. Therefore the scenario that we will be assessing for this sector is as follows:

> **Scenario N1:** Additional output worth USD 359,249 Million has to be achieved by the FPI between 2018 and 2026.

For the implementation of this scenario, top 10 states with Food Processing potential are considered. The share of each of these states in the total value of Gross Output of the FPI and their respective additional output target to be achieved between 2018 and 2026 are given in Table 4.1

These states constitute 80% of the total output in FPI and will be at the forefront in achieving the All India target of USD 535 billion by 2025–2026. The E3 India sector that will be used in this scenario is Food Drinks and Tobacco.

[1] GVA to GVO ratio over the year 2011–2019, lies in the range of 76–79% which is the highest among the major industries. So from capital point of view, it is the most productive industry of the economy (SUT Unit of National Accounts Division).

Table 4.1 State wise share in the National FPI and their corresponding output targets

Sr. No	*States*	*As % of total*	*Targeted output increase to be achieved by 2026 (in USD Million)*
1	Maharashtra	13.42	48203
2	Uttar Pradesh	11.62	41743
3	Gujarat	10.72	38507
4	Andhra Pradesh[a]	10.25	36823
5	Karnataka	8.28	29754
6	Tamil Nadu	8.28	29747
7	West Bengal	5.90	21201
8	Madhya Pradesh	5.67	20378
9	Haryana	4.66	16748
10	Rajasthan	4.01	14413
	All India	100	359249

[a]Andhra Pradesh includes Telangana
Source State wise shares have been calculated based on data from ASI (2017–2018)

Results:

Policy impact across states is measured in terms of the performance of respective states across a number of indicator variables. We begin our analysis by focusing on the Macroeconomic Impact i.e. the impact of the scenario on the overall economy of different states, then we proceed to the Direct Impact where we evaluate the impact felt by the FPI of different states and finally we look at the Indirect Impact, where impact on related sectors of the economy are evaluated.

i. **Macroeconomic Impact**

The macroeconomic impact of the scenario is evaluated using GDP. The GDP results are presented in the following table in terms of the average percentage difference from baseline value of the respective variable over the entire duration of the scenario i.e. 2020–2026.

At the national level, the impact in terms of GDP remains minimal. However, the impact varies from one state to another. Table 4.2 presents the result for the top five states that experience the maximum impact in terms of GDP. **Maharashtra, which leads the nation's FPI, makes the maximum gain in terms of GDP, followed by Rajasthan and West**

Table 4.2 Average % difference from baseline for GDP (2020–2026)

Sr. No	*States*	*% impact*
	All India	0.58
1	Maharashtra	2.40
2	Rajasthan	2.01
3	West Bengal	1.86
4	Uttar Pradesh	0.92
5	Haryana	0.55

Source Results from the model

Bengal. To its credit, Maharashtra has the advantage of a strong raw material base as well as a robust industrial infrastructure that is commonly in place, two critical requirements for the FPI to flourish. The state is a leading producer of several cereals, pulses, and oilseeds (wheat, rice, chickpea, groundnut, and soybean), cash crops (cotton and sugar) as well as fruits and vegetables (mango, banana, grapes, orange, onion, and tomatoes). Additionally, it possesses eight agri-export zones, six national research centres, and several processing clusters (MOFPI, 2017).

The performance of Rajasthan is particularly noteworthy, as the impact in terms of GDP experienced by this landlocked state with a comparatively lower share in the national FPI, is higher than the other states. Major processing units in Rajasthan cater to spices and condiments, milk, fruits and vegetables, snacks, and mustard (MOFPI, 2017). With a tangible impact on the state's GDP, the FPI can be an important sector for the state's economy, playing an instrumental role in providing value addition to agricultural produce thereby assisting in the much-needed income support to the farmers of the state. West Bengal, Uttar Pradesh, and Haryana possess very strong agricultural base and therefore possess a very high potential of benefiting from well-oriented and dedicated FPI policies at the state level.

ii. **Direct Impact**

In order to evaluate the direct impact of the scenario on the FPI of different states, we look at the impact in terms of Employment and Trade.

a. Employment

As noted earlier, the FPI is a major employment provider, therefore we would expect some tangible impact of the scenario in terms of employment, varying across states to a certain extent. Similar to the previous variable, the top five states with maximum impact are shown in the Table 4.3.

West Bengal and Uttar Pradesh have significantly higher employment gains as compared to the other states. These are also two of the highly populated states in the country, with the maximum number of FP units, registered and unregistered combined. The impact on the other major states is also impressive which testifies the employment generation potential of the industry. Not only can the FPI aid in reducing country's high unemployment levels, but it can also serve as a conducive channel for the surplus labour bottled up in the agrarian sector to transition to the industrial sector. In this respect, FPI serves as a key industry in accelerating the country's structural transformation while simultaneously tackling the inevitable consequences of poverty and widening income distribution.

b. Trade

As the Indian FPI is at a nascent stage, preparing the industry to become dynamically responsive to global demand can go a long way in improving the export potential of the industry. The impact of the scenario on the trade potential of the major states is shown in the Table 4.4.

As can be seen in Table 4.4, at the national level, imports register a higher positive deviation from the baseline as compared to exports. A major reason for this is the fact that the Indian FPI has not been able to align its progress with the changing consumption trends that

Table 4.3 Average % difference from baseline for employment (2020–2026)

Sr. No	*States*	*% impact*
	All India	9.17
1	West Bengal	18.81
2	Uttar Pradesh	15.86
3	Tamil Nadu	8.86
4	Maharashtra	7.64
5	Rajasthan	7.15

Source Results from the model

Table 4.4 Average % difference from baseline for regional exports and imports (2020–2026)

Sr. No	States	% impact on export	States	% impact on import
	All India	3.97	All India	5.13
1	West Bengal	14.96	Gujarat	19.74
2	Gujarat	10.79	West Bengal	10.67
3	Tamil Nadu	10.68	Rajasthan	8.61
4	Uttar Pradesh	7.03	Tamil Nadu	8.56
5	Rajasthan	3.61	Uttar Pradesh	8.21

Source Results from the model

have emerged with rapid urbanisation and demographic shifts. While global demand, especially among developed countries, has advanced from convenience snacking to diet and organic foods, India's FPI exports are currently oriented towards mass market opportunities, dealing mainly in dairy, meat, fresh fruits, fruit juices, and beverages (RBI, 2020).

Among the states that experience the highest impact in terms of exports, West Bengal and Tamil Nadu emerge as the only states where the exports exhibit higher growth than the imports. Both these coastal states inevitably benefit from their proximity to ports which complements their broad agricultural base. Major processed agricultural export items from West Bengal include cereal preparations, dairy products, and processed fruits, juices, and nuts. Tamil Nadu, on the other hand, is the major exporter of prepared and preserved cucumber and gherkins in addition to cereal preparations and processed fruits, juices, and nuts. Gujarat is another coastal state, with well-established links with the global market, which experiences considerable impact on its exports, although the impact remains lower than that on its imports. In addition to the processed items exported by West Bengal and Tamil Nadu, Gujarat also exports a decent amount of guar gum, jaggery, and confectionery and alcoholic beverages (APEDA, 2020a).

For the landlocked state of Uttar Pradesh, growth in terms of imports and exports are almost at par, with the former exceeding by over a percentage. For Rajasthan, on the other hand, the growth in its imports far outperforms its exports.

As the data on state wise agricultural imports is not available publicly, not much can be said about the composition of imports of these states. However, availability of such a database can help the states, especially the landlocked states, to secure wider domestic markets. With the large population that India possesses, the domestic market offers an equally promising opportunity for the FPI. For the landlocked states, this may even prove to be a cost-effective alternative. However a detailed analysis of the same is beyond the scope of this chapter.

iii. **Indirect Impact**

All sectors in an economy are inextricably linked and for an industry like the FPI, that facilitates the linkage between the primary and secondary sectors of the economy, the associated linkages possessed in the process are numerous. It is by the virtue of these linkages that any increase in the output of the FPI propels the output of several other sectors.[2] Table 4.5 categorises such sectors in three bins depending on the average growth registered by these sectors at the national level. Further, for each of these sectors, the table provides the states which experience the maximum impact in terms of the average percentage difference from the baseline output over the period under consideration i.e. 2020–2026. The average growth reported in Table 4.5 is indicative of the extent to which the FPI can potentially mobilise the output of the related sectors, provided the FPI is actually able to achieve the additional output target within the stipulated duration as spelled out in this scenario.

The sector which gains the most is the Agricultural sector, which is the source of all critical raw materials for the FPI. This is therefore a classic example of a sector benefitting from backward linkage.[3] **The states whose agricultural sector benefit the most are Maharashtra, Gujarat, and Uttar Pradesh, each of which experiences considerable impact in terms of one or more of the impact variables discussed above.**

The next set of sectors which experience an average growth of 5–10% in their respective sectoral output include Banking and Insurance, Electricity Supply and Construction. Banking and Insurance forms an

[2] The Supply Use Table of 2015-16 also indicate within FPI consumption of its products. This could lead to a virtuous cycle as far as output is concerned. (SUT Unit of National Accounts Division).

[3] The FPI has a very good backward linkage with agriculture. More than 80% of intermediate consumption is agricultural products, therefore similar growth must be experienced by agriculture industry to give rise to the FPI envisioned in the policy. (SUT Unit of National Accounts Division).

Table 4.5 Average % difference from baseline for Inter-sectoral Output (2020–2026)

Average growth range of output (all India)	*Sector*	*States with the highest impact*
Greater than 10%	Agriculture	Maharashtra Gujarat Uttar Pradesh
5–10%	Banking and Insurance	Uttar Pradesh Gujarat Madhya Pradesh
	Electricity Supply	Uttar Pradesh West Bengal Haryana
	Construction	Maharashtra Tamil Nadu Gujarat
Less than 5%	Other Manufacturing	Uttar Pradesh Andhra Pradesh Maharashtra
	Water Transport	Karnataka Haryana Gujarat
	Land Transport	Gujarat Maharashtra Tamil Nadu
	Air Transport	Maharashtra Rajasthan Gujarat
	Hotel and Catering	Gujarat Rajasthan Haryana

Source Results from the model

inevitable input in the capacity expansion of any sector. Majority of the food processing units are medium and small scale enterprises, for the promotion of which both the central and state governments have announced subsidies and credit facilities. The impact of the Banking and Insurance sector on the prospects of the MSME food processing units are explored further in Chapter 10. Construction is another sector that forms an inevitable part of the capacity expansion of the FPI. As noted earlier, the FPI has the largest number of registered factories/ processing units. Any further expansion in the industry's capacity will be necessarily accompanied by an increase in the number of factories. Electricity Supply is a utility that enables the processing units to function, and hence the demand for the sector's output rises with an increase in the output of the FPI.

The last set comprises of those sectors which experience an average growth of less than 5% in their respective sectoral output. The first among these is the Other Manufacturing sector, which is a major source of capital input for the FPI.[4] The transportation sector also contributes immensely to the FPI in terms of procuring raw materials as well as transporting the final output to the market. If the three modes of transportation are clubbed together, the total growth experienced by the industry increases to approximately 9%. Finally, we have the Hotel and Catering sector which provides a market for the FPI output. Quite contrary to the agricultural sector, this sector is a classic example of a sector benefitting from forward linkage. The majority of the sectors discussed above are service based. This implies that the synergy between the agricultural and industrial sector brought about by the FPI is largely aided by the services sector.

Remarks:

If the FPI is able to enhance its production capacity up to USD 535,000 million by 2026, as claimed by the CII with the states' contribution at par with their share in the national FPI as presented in Table 4.1, the most significant contribution that the industry will have at the national level is in terms of employment generation. This contribution remains particularly significant because it has the potential of accelerating the country's structural transformation, provided the necessary skill enhancement programmes are made a priority.

In terms of GDP, the sector does not experience any significant growth over the baseline value. This is inextricably linked to the modest export performance of the industry being overshadowed by the corresponding imports. The global shift in processed food demand from convenience snacking to diet and organic food is already being replicated in the metropolitan cities of India, characterised by faster urbanisation, higher standard of living, higher female labour force participation and greater health consciousness (RBI, 2020). This will soon spread to other cities of the country. The Indian FPI therefore needs to be prepared to be dynamically responsive to demand, not only from the global market but

[4] The FPI uses manufacturing (about 15%) products as its major input. (SUT Unit of National Accounts Division).

also from the domestic market, which can prove to be a major market segment for the industry.

Important states that did not experience any tangible impact in terms of any indicator variable include Andhra Pradesh (and Telangana), Karnataka, and Madhya Pradesh. The case of Andhra Pradesh is particularly intriguing as it has the largest number of registered food processing units across the country. These states should therefore investigate the prospects of their respective FPI and identify structural bottlenecks that are restricting their performance. Overall, the top priorities for the industry should be raising productivity, reducing cost, bringing efficiency in operations and attaining scalability (Sarangi, 2020).

FPI: Maharashtra

In order to augment the above discussion on the regional analysis of FPI in India, we further explore the FPI of the state which leads the nation's FPI and has also emerged as an important state in the results discussed above. This is the state of Maharashtra. Maharashtra is the richest state in India in terms of contribution to GDP and second largest in terms of population. Maharashtra is also one of the most industrialised states in the country, with the shares of industry and services sectors greater than the all India average. The major industries in terms of total gross output are food products and beverages, coke, and refined petroleum products, chemical and chemical products, basic metals and motor vehicles.

With its economy valued at USD 400 billion in 2018, Maharashtra aspires to become a trillion-dollar economy by 2025. In this context, we evaluate the prospect of the FPI, which accounted for 5.8% of the state's total gross output in 2018. In order to maintain its current share in the state's total gross output in a USD one trillion economy, the FPI will have to enhance its production capacity by almost 2.45 times[5] its present capacity. As of 2018, the gross value of food, beverages, and tobacco

[5] In 2018, the gross value of the FPI in the state was USD 23,594 million, accounting for 5.8 percent of the state's total gross output. In order to maintain its share at 5.8 percent under a one trillion dollar economy of Maharashtra in 2025, the gross value of the FPI will have to amount to USD 58,000 million in 2025. Therefore, the additional output that the state's FPI needs to achieve between 2018-25 stands at USD 34,406 million. This is almost equal to 2.45 times its gross value of output in 2018.

industry was USD 23,594 million (EPWRF). Thus the FPI of Maharashtra needs to achieve additional output worth USD 34,406 million between 2018 and 2025 to maintain its share at 5.8%.

In order to evaluate the prospects of the FPI of Maharashtra under a USD one trillion economy, we simulate the E3-India model in a manner such that the target output is assumed to be met by the industry in the given time frame. Results for scenario N1 indicate impressive performance of Maharashtra in terms of GDP and employment, however its performance remains sub-optimal in terms of trade. Therefore, through this extended analysis, we intend to shed some light on the pattern and reasons behind the performance of Maharashtra's FPI as indicated in Scenario N1.

Maharashtra is the leading state in terms of employment in FPI in the organised sector (ASI 2016–2017). Given the labour intensive nature of the industry, we expect an increase in output to be complemented by an increase in employment. Although the state does exhibit considerable impact in terms of employment, it still ranks fourth in terms of the magnitude. This can be understood in the context of the existing infrastructure of the FPI in Maharashtra. Although the state leads in terms of value generated (GVA) in the organised FPI sector, it ranks 5th in the number of registered FP units. Even in terms of unincorporated FP units, the state ranks 3rd with the leading state of Uttar Pradesh having almost 1.5 times more unincorporated FP units than Maharashtra (MOFPI, 2019). The existing capacity of Maharashtra's FPI therefore does not have immense employment generation potential. It is only after a year that the impact on employment becomes tangible, possibly with infrastructure expansion.

The results also suggest that the industry fails to channelise its higher output into higher exports. The fact that industry exports remain low even when the output has increased significantly suggests that there are structural bottlenecks being faced by Maharashtra's FPI in terms of improving its export performance. This becomes all the more evident when we consider the fact that Maharashtra has one of the leading FPI in the country. It is home to several mega food parks, cold storage units, and agri-export units. It is well connected to foreign markets and is among the leading producer of several agricultural commodities. Maharashtra's imperceptible export performance despite these advantages therefore needs to be evaluated in the larger context of the overall export competitiveness of the Indian FPI.

At present, India's agricultural exports predominantly consist of raw materials, which are then processed in other countries. In fact, less than 10 per cent of the agricultural/food items is processed domestically. Apart from the challenges that restrict food processing output, there are additional hurdles that impair its export performance. The biggest of which is the tightening of the quality standards by the importing nations. In order to comply with the norms of the importing nations, it is required to procure the produce from registered farmers only. However, India's agricultural sector remains largely unorganised which may affect exports adversely. Moreover, there is a lack of awareness among prospective exporters on existing schemes and policies related to exports, as well as the documentation and procedures to be followed for exports. In addition to capacity building domestically, it is important for the industry to tap new export markets and strive towards increasing its share and competitiveness in the global market. The same applies to the FPI of Maharashtra, too.

An important observation that can be made from the discussion on the inter-sectoral impact presented in Table 4.5 is that in the case of Maharashtra, the sectors that benefit from increased output of the FPI are **highly emission intensive industries**. These primarily include the Land and Air Transport sector, Construction, and the Agricultural sector. In light of this observation, evaluating the impact that this scenario yields on the environment becomes pertinent. For this purpose, we trace this impact in terms of **CO2 Emissions**.

Figure 4.1 demonstrates that the emission intensity of this particular scenario is very high, with the emissions experiencing a positive deviation from baseline as high as 15.7% in 2025. Thus, we can conclude that while the FPI has the potential to contribute significantly in terms of GDP and employment, the industry delivers these benefits at the cost of the environment.

Remarks:

If Maharashtra's FPI is able to maintain its current share in the state's economy until 2025, the industry will play an instrumental role in helping Maharashtra achieve its target of becoming a one trillion dollar economy by 2025. The industry delivers promising results in terms of generating employment and boosting GDP. In case the FPI fails to maintain this share, the results will not be so favourable. On the other hand, if this share increases, the results will be even more promising. However, given this potential, it is equally important to ensure that the industry operates at its highest potential where the economy-environment trade-off is minimised

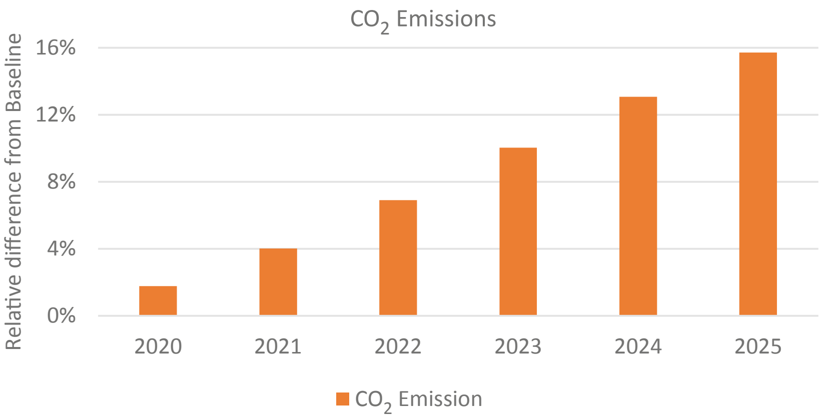

Fig. 4.1 Impact of increased output of Maharashtra's FPI on CO_2 emissions (in %) (*Source* Results from the model)

simultaneously. In order to achieve this, there are a few areas that require policy attention:

i. This scenario illustrates that higher output alone cannot ensure better export performance even for a state like Maharashtra which is currently leading the FPI and is well connected to global markets. As long as exclusive policy attention is not directed towards increasing logistical efficiency, ensuring a more diversified basket of better quality products for securing new markets and addressing the challenges being faced by exporters, the export prospects of the industry will remain gloomy.
ii. Urbanisation drives the demand for processed food and beverages (RBI, 2020). As one of the most urbanised state in the country, Maharashtra possesses a huge domestic market for its FPI. This is evident from the increasing imports despite an increase in the domestic output of the FPI. In order to be able to cater to its domestic market, Maharashtra will have to focus on improving its competitiveness, initially with respect to other states and then with respect to other countries.
iii. Another key area which requires policy intervention is the environmental aspect. As noted earlier, the agricultural, transport, and power sector are critical for facilitating an increase in the output

of the FPI. This makes the overall energy intensity of the FPI very high. Therefore, devising alternatives to keep the emissions in check becomes an equally important task. The first step towards controlling emissions within the FPI can be to experiment with the energy mix of Mega Food Parks and Agri-export Units and to analyse the feasibility of replacing conventional energy sources with renewable energy. Beyond the FPI, prospects of renewables should also be explored for its supporting industries, especially the Transport Sector.

2. Agriculture Exports Policy (AEP), 2018

In terms of agricultural trade, India has consistently remained a net exporter of agricultural commodities since 1991, with the share of agricultural exports in India's total exports amounting to 12.80% in 2017–2018. However, India's share of total global agricultural exports has remained at the lower end. The Agriculture Export Policy, 2018 therefore aims to double agricultural exports from the present USD 30 + Billion to USD 60 + Billion by 2022 and reach USD 100 Billion in the next few years thereafter, with stable trade policy regime (GOI, 2018b). India's agricultural export basket is led by rice, marine products, and meat which together constitute 52% of the total agricultural exports from India. Meanwhile, the share of value added agricultural produce in its agricultural export basket remains less than 15% as compared to 25% in US and 49% in China.[6] With this policy therefore, the government also aims to increase the share of value-added products in the total agricultural exports of India. We assume that the target of USD 100 Billion has to be reached by 2025. Additionally, in order to address the concern regarding increasing the share of value-added products in the total agricultural exports of India, we assume that by 2025, India is able to increase the share of value-added products to 25%.

For this scenario, therefore, the target for primary agri-exports and processed agri-exports to be achieved by 2025 stands at USD 75 billion and USD 25 billion, respectively. As of 2018, agri-exports worth USD 40 Billion had been achieved, out of which primary agri-exports amounted to

[6] The overall export of FPI products is 10%. However, some category of products have higher export share such as processed fish and fish products (75%), processed poultry product (46%), processed coffee (32%). (SUT Unit of National Accounts Division).

USD 34 billion while processed agri-exports amounted to USD 6 billion. Thus the additional export target to be achieved is stated in the scenario described below:

> **Scenario N2:** Additional agricultural exports worth USD 60 Billion has to be achieved by 2025 with the share of processed agricultural exports in the agri-export basket amounting to USD 19 billion.

For the implementation of this scenario, the top 10 states with agricultural export potential are selected. The share of each of these states in the total agricultural export and their respective additional export target to be achieved between 2018 and 2025 is mentioned in Table 4.6. These states together constitute 90–95% of the total export of major agri-products from India during the year 2019–20. These states will therefore be instrumental in driving India towards its target of achieving Agri-exports worth USD 100 billion by 2025.

Table 4.6 State wise share in the national agricultural exports and their corresponding export targets

Sr. No	*State*	*Share in primary agri-exports (%)*	*Primary agri-exports target (USD Mn)*	*State*	*Share in processed agri-exports (%)*	*Processed agri-exports target (USD Mn)*
1	Gujarat	30.7	12,587	Maharashtra	31.6	6004
2	Maharashtra	20.7	8487	Gujarat	21.1	4009
3	Uttar Pradesh	13.9	5699	Tamil Nadu	12.3	2337
4	Haryana	7.3	2993	Rajasthan	6.3	1197
5	Tamil Nadu	6.2	2542	Karnataka	5.2	988
6	Andhra Pradesh	5.3	2173	Uttar Pradesh	4.9	931
7	West Bengal	4.2	1722	Kerala	4.0	760
8	Punjab	2.8	1148	Andhra Pradesh	3.1	589
9	Bihar	1.8	738	West Bengal	2.5	475
10	Karnataka	1.7	656	Haryana	2.4	456
	All India	100	41,000	All India	100	19,000

Source State wise shares have been calculated from the data available on APEDA Agri Exchange

Results:

Similar to the previous scenario, we analyse the impact of this scenario in terms of Macroeconomic Impact, Direct Impact, and Indirect Impact. The results are given below:

i. **Macroeconomic Impact**

The macroeconomic impact of the scenario is evaluated in terms of GDP and the same is presented in Fig. 4.2 for the top five states.

Among the states, Gujarat experiences the maximum gain in terms of GDP. Gujarat, Maharashtra, and Tamil Nadu, being coastal states, with comparatively well-developed infrastructure to facilitate exports are able to translate their agricultural output into exports. The performance of Maharashtra still remains sub-optimal given its large share in the national agricultural exports. The landlocked states of Haryana and Uttar Pradesh are the principal beneficiaries of the nation's Green Revolution, and hence the top contributors to India's food grain production and export.

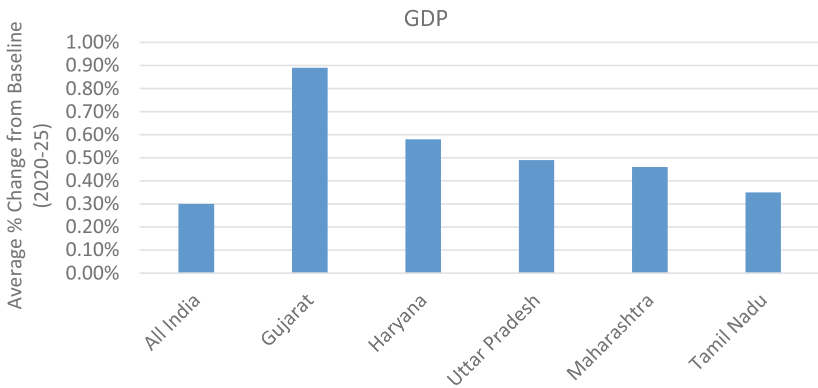

Fig. 4.2 Macroeconomic impact of the agricultural export policy, 2018 (in %) (*Source* Results from the model)

ii. **Direct Impact**

In order to evaluate the direct impact of the scenario on the agriculture and food processing sector of different states, we look at the impact in terms of Output and Employment. Table 4.7 presents the results for Output.

At the national level, the average gain in terms of agricultural output stands at around 4% however there are large inter-state variations that can be noticed, with the state of Gujarat experiencing an average growth as high as nearly 17% while Uttar Pradesh shows an average growth of about 5% only. This variation stems from the trend that Indian exports have been heavily dominated by a few large states of which Gujarat and Maharashtra are the biggest contributors. In case of the Food processing sector, the increase in output at the national level is negligible indicating that without better infrastructure to promote processed agricultural exports, the industry's performance will hardly differ from the business as usual case. At the state level, Gujarat and Tamil Nadu make the maximum gain, indicating the potential of the states' FPI. The increase in the output of FPI of Haryana and Uttar Pradesh remains incommensurate indicating that they fail to complement their abundant agricultural output with adequate processing infrastructure, which truly reflects the current reality of these states. West Bengal emerges among the top five states in terms of FPI output even though it ranks lower in terms of agricultural output. This result is indicative of the potential of the FPI of the state, which was also highlighted in the previous scenario.

Table 4.7 Average % difference from baseline for output (2020–2025)

Sr. no	*Agriculture*	*% impact*	*Food, drink and Tobacco*	*% impact*
	All India	3.97	All India	0.25
1	Gujarat	16.95	Gujarat	1.62
2	Maharashtra	9.58	Tamil Nadu	1.05
3	Haryana	6.94	Haryana	0.27
4	Tamil Nadu	5.99	West Bengal	0.19
5	Uttar Pradesh	4.66	Uttar Pradesh	0.15

Source Results from the model

The impact on employment generation remains minimal, with the average growth remaining below 1% for both agriculture and food processing sector for all states. **The states which experience the largest impact in terms of employment in agriculture sector are Maharashtra, Gujarat, and Uttar Pradesh, while those in the food processing sector include Tamil Nadu, Gujarat, and Maharashtra.** The fact that both these sector exhibit similar proportion of growth in employment even when the agriculture sector experiences higher output growth points to the fact that employment in agriculture has already saturated, with ample evidence of disguised unemployment. On the other hand, the FPI is currently at its nascent stage, and any expansion of the industry's output and exports will generate employment opportunities, as indicated in the previous scenario.

ii. **Indirect Impact**

Table 4.8 lists the sectors that gain the most from the increased exports of the agriculture and food processing sectors. Unlike the previous

Table 4.8 Average % difference from baseline for sectoral output (2020–2025)

Sr. no	*Sector*	*State*	*% Impact on Output*
1	Chemicals	Haryana	2.37
		Punjab	2.04
		Uttar Pradesh	1.01
2	Land transport	Tamil Nadu	4.14
		Gujarat	2.66
		Maharashtra	1.14
3	Air transport	Gujarat	3.36
		Maharashtra	1.12
4	Electricity supply	Haryana	1.98
		Maharashtra	1.18
		Tamil Nadu	0.88
5	Banking and insurance	Gujarat	2.18
		Haryana	1.25
		Uttar Pradesh	0.93
6	Hotel and catering	Gujarat	9.59
		Haryana	2.27
		Punjab	1.23

Source Results from the model

scenario, these sectors are not categorised in separate bins as the average growth registered by all these sectors remains below 5%. This is because the sectors of concern in this scenario i.e. the agriculture and food processing sectors themselves do not register considerable impact, and hence the indirect impact remains limited as well. Therefore, instead of showing the average national growth, Table 4.8 mentions the state level impact for each sector.

The Chemical Sector includes fertilisers and pesticides, important inputs to agricultural production, hence benefitting from increased agricultural production. The states that experience the maximum impact in this sector are Haryana, Punjab, and Uttar Pradesh, all of which are responsible for a major share of the nation's agricultural output. Electricity Supply and Banking and Insurance benefit similarly from backward linkages. Land and Air Transport assists the agricultural and food processing sectors as discussed in the previous scenario, and hence experiences increase in its output with an increase in the output of the sectors of concern in this scenario. Finally, Hotel and Catering, which serves as a major consumer segment of both agricultural and food processing sectors, benefits from the inherent forward linkage. The impact experienced by the Hotel and Catering sector in Gujarat remains commendable.

The fact that Trade and Logistics sector does not experience any tangible impact from an export oriented scenario is indicative of the inefficient supply chain management ailing the agricultural exports. The lack of sufficient warehousing and cold storage facilities is a well-known impediment to Indian agricultural exports. Moreover, existing warehousing facilities remain disproportionately concentrated in a few regions (Jain, 2017). Poor logistics are estimated to add 6–8% to India's Free On Board (FOB) cost vis-à-vis developed countries like Germany, Singapore, Hong Kong, etc. (Sarangi, 2020).

Remarks:

These results suggest that the country will not be able to reap significant benefits from achieving its target of reaching agricultural exports worth USD 100 Billion by 2025, unless urgent and substantial efforts are dedicated towards identification and redressal of the infrastructure and logistical gaps in the supply chain. The importance of Logistics for both agriculture and food processing sectors cannot be stressed enough. By providing essential services such as warehousing and cold storage, the sector ensures that wastage and hence losses are minimised. Any tangible impact would therefore require deep rooted structural changes that increase India's integration in the global agri-export value chain, which would in turn require strengthening the processing capacity of the country.

The three priority areas include the following: First and foremost, our cropping pattern needs to be dynamically responsive to demand for which the farmers need to be made aware of global demand and its changing pattern. Secondly, in order to ensure that their produce qualifies for exports, they also need to be aware of the quality standards in place and the changes in agricultural practices, such as a reduction in the use of chemical fertilisers and pesticides, which would help them comply with those standards. Moreover, capacity building and skill enhancement of exporters are indispensable to enhancement of export potential.

To its credit, APEDA is in the process of identifying major export clusters across major states, which will be critical in boosting the agricultural and horticultural production in India. Additionally, it has also identified the projected potential markets for certain processed products (APEDA, 2020b). While this is commendable, it is equally important and moreover urgent, to identify states that possess competitive advantage in these products.

Overall, the AEP 2018 is a very comprehensive policy which has been able to identify major bottlenecks restricting the country's agricultural export performance. The strategic and operational recommendations of the policy are wide-ranging and equally critical. For the same reason, successful implementation of the policy would require reasonable progress in all the areas identified by the policy, because otherwise the country does not stand to gain much with its current infrastructure and export orientation, as indicated by the results discussed above.

In line with AEP 2018, many State governments have come up with their own state level agriculture export policies to outline the plan of action for achieving the national target. The government of Uttar Pradesh (UP) is one such state which has not only drafted the Uttar Pradesh Agricultural Export Policy 2019 in line with the recommendations of AEP 2018, but has also set forth its own state-level targets that it intends to achieve by 2025 (Govt. of Uttar Pradesh, 2019). As indicated by the results of this national scenario, UP emerges as one of the top five performers across all indicators and it is therefore worthwhile to analyse its export policy to derive deeper regional insights. And so, to take this analysis further, we consider UP's AEP as our first regional scenario, presented in the next section.

4.4 Regional Scenarios

1. **Uttar Pradesh: Agriculture Export Policy 2019**

Much like Maharashtra, UP aspires to become a trillion dollar economy by 2025 and the state considers Agricultural exports to be the key to achieving this objective (Kumar, 2019). The state, which is the 3rd largest contributor to the GDP, is predominantly agrarian with around 66% of its population engaged in agriculture and allied activities. With nine different agro-climatic zones, UP is the leading producer of food grains, sugarcane, milk, meat, and potato in the country. Major export items of the state include buffalo meat, wheat, Basmati and non-Basmati rice, honey, fresh mangoes, dairy products, and processed fruits, juices and nuts.

In 2018–2019, the state's share in national Agricultural exports stood at 7.35%, amounting to USD 2,524 million. The policy envisions to double the agricultural exports by 2024. The policy also intends to shift its export orientation from unprocessed agricultural produce to value added products. The Food Processing Policy 2017 of Uttar Pradesh had set a target of achieving a level of value addition and processing up to 20% by 2022 from 6% in 2017 (Govt. of Uttar Pradesh, 2017). However, in 2019–20, the share of value added products in UP's agricultural export basket hovered around 7.5%. In order to incorporate the policy objective of increasing the share of value added products in exports in a realistic manner, we assume that by 2024, UP is able to double the share of the value-added products in its agri-export basket to 15%. Thus the scenario to be analysed for the state of UP can be summarised as below:

> **Scenario R1:** Additional agricultural exports worth USD 2,524 Million has to be achieved by 2025 with the share of processed agricultural exports in the agri-export basket amounting to USD 389 Million (~15%).

In order to evaluate the impact yielded by the doubling of agri-exports on the economy of UP and the agricultural and food processing sector of the state, we simulate the E3-India model in a manner similar to that of scenario N2, except that for this scenario the stimulus is provided to the state of UP only. The results are presented below:

Results:

1. **Macroeconomic Impact**

As depicted by Fig. 4.3, the macroeconomic impact of the policy remains minimal. The declining trend observed in all variables indicates that the state does not have the capacity to sustain this increase in its exports, even if it is able to achieve it. The impediments hindering UP's export potential are no different from those at the national level, identified in the previous scenario. Poor value-addition capability and inefficient supply chain management are at the core of these impediments.

The state has the highest number of unincorporated enterprises manufacturing food and beverages (MOFPI, 2019), who mainly rely on low productive technology for their production processes and face problems in accessing marketing opportunities. According to a 2012 survey, 53% of agro-units, comprising 54% registered and 52% unregistered units were using second hand machines in production processes due to the high purchase cost, lack of finances, less supply, and non-availability of modern machines in local markets (Mehta, 2012).

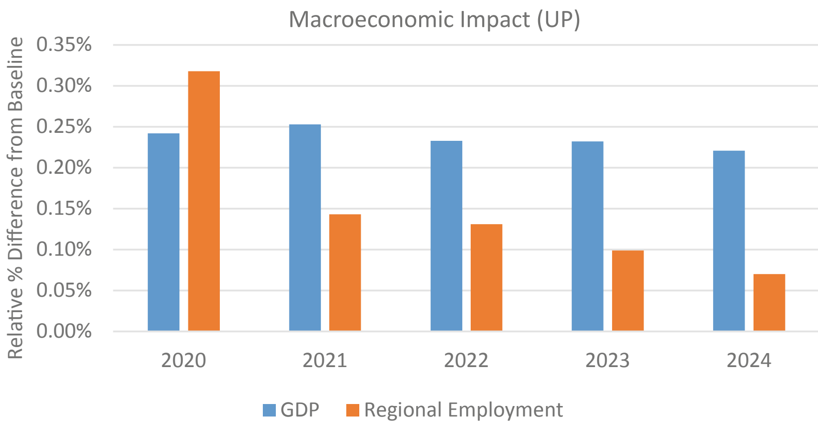

Fig. 4.3 Macroeconomic impact of the Uttar Pradesh Agricultural Export Policy 2019 (in %) (*Source* Results from the model)

2. **Direct Impact**

The direct impact of the policy is evaluated in terms of Output and Employment of Agriculture and the Food processing sector. The relative difference from the baseline Industrial Output for both the sectors is presented in Table 4.9.

Table 4.9 Relative % difference from baseline for output

Sector	*2020*	*2021*	*2022*	*2023*	*2024*
Agriculture	2.33	2.41	2.38	2.40	2.38
Food, Drink and Tobacco	0.12	0.10	0.09	0.07	0.06

Source Results from the model

The Agricultural sector experiences an average increase of around 2.4% from the baseline. Although the impact is reasonable, but given the state's position as the leading producer of food grains, this result lacks parity with its potential. The impact on the output of the Food Processing sector, on the other hand, remains negligible, indicating that the industry's output is not particularly well integrated with the agri-export supply chain.

In terms of Employment, the impact remains below 1% throughout, declining as we move from 2020 to 2024. While the agriculture sector fails to create employment opportunities as it is already burdened with disguised unemployment, the food processing sector does not experience sufficient impact in terms of output expansion to generate additional employment opportunities.

Remarks:

The results derived from this regional scenario suggest that the overall trend of major indicators is in sync with that of scenario N2, with the magnitude varying due to the difference in magnitude of the targets of the two scenarios itself. Given UP's current infrastructure, the objectives outlined in the state's AEP are ambitious but also critical. The narrower the gap between the formulation of the policy and its implementation, the more the state will stand to gain from it. Ensuring efficiency in the following areas is crucial for the successful implementation of the policy:

i. The state currently ranks third in terms of contribution to national GDP but also ranks fourth in terms of unemployment. With a large section of the population dependent on agriculture, improving the productivity of the sector becomes inevitable. Unlike other major beneficiaries of the Green Revolution, like Haryana and Punjab, the farm mechanisation of the agricultural sector has been limited in UP (Rawat, 2013). The same trend is visible in its food processing units, where grading, labelling, and packaging of agro-products is mostly done manually. Moreover, use of quality control devices was restricted to a small proportion of the organised segments (Mehta, 2012).

ii. The overarching requirement for enhancing the export potential of the state is a stable trade policy. While the state has identified the agricultural, processed and organic food products along with their respective clusters for the implementation of the policy, the main challenge will be to create an environment where its farmers and exporters are able to factor in market volatility in their decisions. Apart from a stable trade regime, domestic stability is also a prerequisite in achieving the stated objective. Strengthening the efficiency of state's banking sector to ensure easy access to credit, ensuring constant supply of electricity and access to international markets for both agricultural and food processing sector can smooth out a lot of disruptions currently being faced by the stakeholders.

2. **Rajasthan: Doubling Farmers' Income**

The Central Government aspires to Double Farmer's income by 2022. The key interventions to achieve the target are in the following sectors—(a) Focus on irrigation with large budgets, with the aim of 'per drop, more crop', (b) Provision of quality seeds and nutrients based on soil health of each field, (c) Investments in warehousing and cold chains to prevent post-harvest crop losses, (d) Promotion of value addition through food processing, (e) Creating of a national farm market, remove distortions and develop infrastructure such as e-platform across 585 stations, (f) Strengthening of crop insurance scheme to mitigate risks at affordable cost, and (g) Promotion of ancillary activities like poultry, bee-keeping, and fisheries.

In this context, a study was undertaken by NABARD to analyse how a preliminary investment infusion can assist in raising farmer's income in the largest Indian state, Rajasthan. The state covers 10 agro-climatic zones which have propelled the state in being the largest producer of mustard, cluster beans, pearl millet and spices such as coriander, cumin and fenugreek. It is also the second largest producer of maize. As per the report published by NABARD titled 'Doubling Farmer's Income: Issues and Strategies for Rajasthan, 2018' an additional investment of INR 116,000 million (USD 1,657 million) needs to be undertaken in sectors linked to agriculture for the state to achieve this target (NABARD, 2018a).

Scenario R2: Additional investment worth USD 1,657 million needs to be made in the agricultural sector of Rajasthan by 2022.

In order to evaluate whether this investment is able to achieve the stated objective, we simulate the E3-India model in a manner such that the stated investment is assumed to have been made in the given time frame. With this stimulus in place, we analyse the impact of this investment through several macroeconomic indicators which are presented below:

Results:

As the objective of this investment is to double the income of farmers, we begin our analysis by looking at the impact of this investment on employment and income. Subsequently, we analyse the impact this investment yields on the agricultural sector as a whole as well as the overall economy through impact variables such as output, product exports, and the state's GDP.

1. **Employment and Gross Disposable Income (GDI)**

Here we consider GDI as a proxy for farmer's income. The impact that the stated investment yields in terms of employment and GDI is shown in Fig. 4.4.

Employment increases as a result of the investment made in the agricultural sector, reaching 1.46% above baseline in 2022, beyond which it starts declining. By 2025, the impact on employment is less than 1%. Overall, the impact remains minimal.

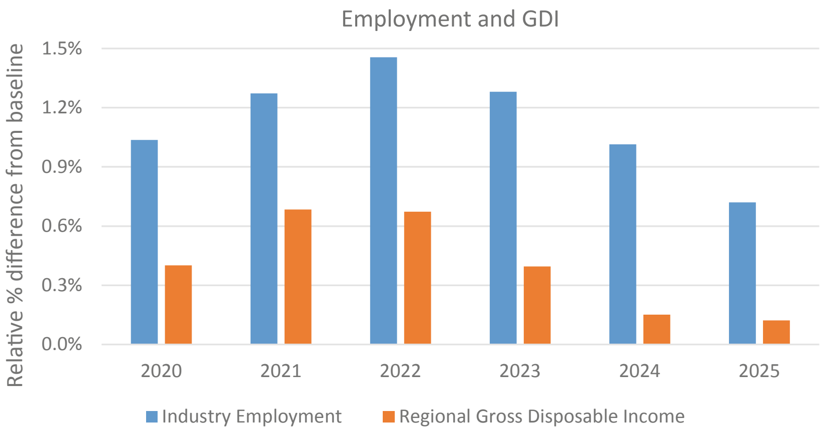

Fig. 4.4 Relative % difference from baseline for Employment and GDI (*Source* Results from the model)

In terms of GDI, the impact remains even more nominal. With everything else remaining constant, we would expect any sign of doubling of farmers' income to be reflected in the GDI. However, the maximum positive deviation that is achieved in terms of GDI is only 0.68%, in 2022, beyond which it starts declining. Even though the investment plays a role in enhancing farmers' income marginally in the initial few years, it is nowhere close to the scale that would be expected to double farmers' income. Also, given that the GDI returns close to the baseline value by 2025, we can conclude that this investment serves as a short term stimulus only, failing to be beneficial in the long run. Thus, this investment fails to be sustainable. The objective of Doubling Farmers' income by 2022 will therefore need additional stimulus.

2. **Other Impact Variables**

Having seen the impact of the investment infusion on employment and income, we now try to evaluate the impact of this investment on the agricultural sector and the overall economy of Rajasthan through other macroeconomic variables. For this purpose we consider Output, Exports, and GDP and the results are presented in Table 4.10.

Table 4.10 Relative % difference from baseline for output, exports and GDP

Impact variable	*2020*	*2021*	*2022*
Agricultural Output	2.88	2.65	2.57
Exports	0.15	0.16	0.17
GDP	2.11	1.89	1.68

Source Results from the model

Agricultural Output: Results indicate that the investment yields nominal impact on the output of the sector, with the maximum impact realised in 2020 itself. However, as noted previously, the corresponding increase in income remains incommensurate.

Exports: Exports remain abysmally low. This indicates that the investment infusion fails to channelise the higher output into higher exports, suggesting that the link between output and exports is broken. This is a matter of concern given that Rajasthan is the leading producer of a number of crops including mustard, pearl millet, cluster bean, Psyllium Husk, Henna and Coriander. It is also the second largest producer of Cumin and Pulses (total) in the country (NITI Aayog, 2016). Poor export performance can be a major factor constraining farmers' income.

GDP: GDP follows the same pattern as Agricultural Output, experiencing the maximum impact in 2020 with the impact declining in the following years. This declining trend in both output and GDP indicates that the state currently lacks the infrastructure to translate its investment into output in a sustainable manner.

Remarks:

As discussed above, the stated investment infusion enhances farmers' income only in the short run, and that too marginally. A long term impact on the same would require additional stimulus of a greater extent. Given the peculiarities of the state in terms of its extreme temperatures, erratic rainfall and poor soil health, there are a few areas that require policy attention:

i. Recent initiatives of the state government have highlighted three priority areas for the sector: making barren land productive, improving shelf life of agricultural produce that would improve the go-to-market value for farmers and tackling water scarcity in cultivation (Inc42 BrandLabs, 2020). However, identifying the focus areas is just the first step. Without adequate investment in Research and Development in each of these areas, any tangible improvement will remain a distant dream.

ii. Developing robust export channels can go a long way in enhancing farmers' income. Apart from a strong processing sector, there are a number of changes that will be required in the farm sector itself. These include use of higher quality (organic) and lower quantity of fertilisers and easy availability of credit, in addition to the key focus areas highlighted in the previous point. Given that the state is already exploring new horizons in terms of Olives, Date-palm, Jojoba, and Dragon Fruit plantation (NITI Aayog, 2016), development of a strong food processing sector should be a priority for the state.

iii. The state does have a number of schemes in place that can play a crucial role in achieving the stated objective. These include soil health cards, adoption of certified seeds and improving/expanding extension services via Information and Communication Technology (ICT) (Mittal, 2018). Sincere implementation and continuous improvement though a feedback mechanism can ensure that these initiatives get translated into the anticipated benefits.

4.5 COVID-19 Scenarios

1. Agriculture Sector

With the onset of a global pandemic, the entire economy has taken a deep plunge and the agriculture sector is no exception. As the nationwide lockdown coincided with the harvesting season for Rabi crops, there were far-reaching consequences experienced by the agricultural sector. Although the sector was categorised as an essential sector and was exempted from the lockdown three days after the initial lockdown announcement, the inconsistencies in the agriculture supply chain and production system were already visible (Rawal & Verma, 2020). The mass exodus of migrant workers back to their rural hometowns resulted in a severe labour shortage at the peak of the harvesting season. This labour shortage also impacted further handling of the crops in terms of processing and packaging (APEDA, 2020c). Restrictions on inter-state movement blocked the movement of crops and consequently their sale.

Storage and other logistical problems have added to the woes of the sector.

Moreover, this impact has not been solely on the supply disruptions. The pandemic has also depressed demand. With hotels and restaurants closed, a major source of demand has been cut off. As employment and income plummeted, the demand for perishable commodities like fruits and vegetables also declined. In addition to this, the poultry sector suffered from the misinformation related to the transmission of the virus through consumption of meat and eggs. The sectors that have been affected the most are dairy farming, floriculture, fruit production, fisheries, and poultry farms (Kumar et. al., 2020).

In this scenario, we intend to evaluate the impact of the pandemic on the agriculture sector across Indian states. For this purpose we have used the amount of loss reported by different sub-sectors of the agriculture sector between February and May. Table 4.11 shows the sub-sectors incorporated in this scenario and their corresponding loss amount.

Table 4.11 Loss amount reported by different sub-sectors of the agricultural sector (in USD million)

Sr. no	*Sub-sector*	*Loss Amount (USD Million)*
1	Fruits and Vegetables	7143
2	Poultry Sector	3214
3	Seafood Industry	571
4	Jute	179
5	Coffee	105
	Total	11,212

Source: Kasabe et al. (2020), Krishnakumar (2020), Bhagat (2020), and Press Trust of India (2020)

Results:

For each macroeconomic variable, we analyse the impact of COVID on the agricultural sector of different states in two steps: First, we look at the short run impact that the reported losses yield on different states in 2020 and then we analyse the time that these states take to recover from the crisis and return to the baseline level of exports, employment, etc.

1. **Output and Employment**

a. Short run Impact

Table 4.12 highlights the short run impacts of the pandemic on the output and employment of the agricultural sector at both the national and the state level. Impacts on the top seven states are included in the table.

At the national level, agricultural output shrinks by 6.57%, while the corresponding decline in employment is 1% below baseline. The country witnessed significantly higher sowing for winter crops as compared to the last season. In terms of area, record sowing was achieved by the state of Gujarat, with the area under wheat, maize, pulses, and onion cultivation increased considerably (FE Bureau, 2020). Consequentially, by the time the nationwide lockdown was announced, the country had a bumper winter crop ready for harvest. However, severe labour shortages, transport bottlenecks and plummeting demand translated into huge losses for millions of farmers (Pasricha, 2020). There was a massive contraction in the amount of crop produce that was sold in the mandis (Rawal & Verma, 2020). Nearly 90% of the farmers were unable to harvest/sell produce or have sold it at reduced prices between April 13 and May 9 (FICCI, 2020). This explains the large decline in agricultural output observed in Table 4.12 at both national and state level.

Table 4.12 Short run impact in terms of output and employment of agricultural sector (2020) (in %)

Sr. No	*States*	*% impact on output*	*States*	*% impact on employment*
	All India	−6.57	All India	−1.00
1	Maharashtra	−11.21	Punjab	−4.08
2	Uttar Pradesh	−10.53	Uttar Pradesh	−2.61
3	Tamil Nadu	−9.65	Maharashtra	−2.56
4	Karnataka	−8.07	Gujarat	−1.74
5	Haryana	−7.44	Haryana	−0.59
6	Gujarat	−7.43	Rajasthan	−0.33
7	Punjab	−6.38	Madhya Pradesh	−0.30

Source Results from the model

As shown in Table 4.12, the states which depend on migrant agricultural labourers experience the greatest impact in terms of employment. Even UP, which is a major provider of agricultural workers to Haryana and Punjab, experiences a drop in its employment. The combined fear of getting infected as well as getting quarantined prevented workers from going to the fields to work (Kraret al., 2020).

b. Revival of Output and Employment

Table 4.13 indicates the number of years that the states mentioned in Table 4.12 take to return the baseline value of Output and Employment.

Unless significant progress is made in terms of mechanised agriculture, revival of agricultural output will remain dependent on revival of employment, and the same is indicated by the results in Table 4.13. Poverty and lack of alternate employment opportunities may force these labourers to retrace their steps to the fields of neighbouring states. This might be an explanation for the fact the states closest to Bihar, Uttar Pradesh, and Odisha, home to the majority of migrant labourers, are the ones to revive their employment within one year. These include Madhya Pradesh, Punjab, and Haryana. Maharashtra and Rajasthan being further away, take 2–3 years for the revival of their employment. Once employment revives, output follows. For the states that take more than 3 years to revive their output, the average difference between the baseline and the projected output remains less than 1% in 2023.

Table 4.13 Number of years required to return to baseline

Number of years required	*Key states—Output*	*Key states—Employment*
1 year	-	Uttar Pradesh Gujarat Madhya Pradesh Punjab Haryana
2–3 years	Tamil Nadu Uttar Pradesh	Maharashtra Rajasthan
Greater than 3 years	Gujarat Punjab Haryana Karnataka Maharashtra	-

Source Results from the model

Table 4.14 Short run impact in terms of trade of agricultural sector (2020) (in %)

Sr. no	*State*	*% Impact on Exports*	*State*	*% Impact on Imports*
	All India	−0.90	All India	−0.93
1	Gujarat	−1.39	Kerala	−2.04
2	Rajasthan	−0.89	Tamil Nadu	−1.99
3	Haryana	−0.87	Gujarat	−1.45
4	Maharashtra	−0.86	Maharashtra	−1.20
5	West Bengal	−0.85	Haryana	−1.12

Source Results from the model

2. Trade

Table 4.14 shows the short run impact on the trade of the agricultural sector at the national level as well as across the top five states.

a. Short run Impact

At the national level, the difference between the proportion of decline in imports and exports remain negligible. At the state level, the negative impact on the top five states in terms of exports is exceeded by their respective imports. As India has been a net exporter of agricultural products, greater decline in imports, mainly on account of lower demand, suggests improvement in the agricultural trade surplus.

The decline in exports, on the other hand, is not only attributable to depressed global demand but also to domestic supply chain inconsistencies and labour shortages. For instance, in Maharashtra, Asia's largest onion trading market in Lasalgaon struggled to ship its freshly harvested crop to countries like Malaysia and in the Middle East. Similarly, grape farmers in Pune, Maharashtra, who are usually able to export their produce, were forced to sell it in the local market at much lower prices. As the storage facilities were already full, they were accepting whatever price was being offered for their perishables (Pasricha, 2020). The restrictions imposed due to the Covid-19-induced lockdown has also prevented tea exporters in West Bengal and Assam in fulfilling orders from US, Britain, Germany, and China (Ghosal, 2020).

b. Revival of Trade

Table 4.15 reports the expected time the states mentioned in Table 4.14 will take to return to the baseline value of exports and imports. Results suggest that imports revive sooner than exports. However, this should not be a serious threat to the agricultural trade surplus in any manner as currently exports exceed imports by a significant amount. For both exports and imports, the states that are able to revive their trade in the shortest possible time are coastal states.

Remarks:

The Agricultural sector has been reeling under uncertain market conditions induced by the COVID-19 pandemic. A study by the Food and Agricultural Organisation of the UN suggests that the supply-side shock to which India's exposure is the greatest is a fall in gross output per agricultural worker. On the other hand, the country's exposure to demand side shocks will be the highest in terms of a decline in share of food expenditures per capita. The study also reports that India's degree of exposure to supply and demand shocks induced through exports and imports will remain low (Schmidhuber et al. 2020). This highlights two important policy priorities for the sector: First, ensuring that the gross output per agricultural worker revives as soon as possible and second, exploiting the potential of Agri-exports to help the sector revive from the crisis.

Table 4.15 Number of years required to return to baseline

Number of years required	*Key states- Exports*	*Key states- Imports*
1 year	-	Kerala Gujarat Tamil Nadu
2–3 years	Gujarat Maharashtra West Bengal	Haryana Maharashtra
Greater than 3 years	Rajasthan Haryana	-

Source Results from the model

The decline in the gross output per agricultural worker was prompted through a mix of labour shortage and lockdown restrictions. In order to prevent contraction of agricultural produce sold, Punjab and Haryana, expanded the number of markets from where it will be picked up to prevent crowding and ensure that social distancing was maintained. However, such measures were restricted to these states. Farmers in Rajasthan were forced to sell their produce at much lower rates than the Minimum Support Prices (MSPs) after procurement was delayed by State-owned procurement agencies by almost two weeks. This had a disproportionate impact on small and marginal farmers who do not possess the means to hold their produce till the procurement begins (Jayan, 2020).

An important consideration to be kept in mind is that government procurement is not a panacea to farmers' woes. High government procurement, particularly for this season's bumper wheat harvest, is likely to add to the burden of already existing stock and simultaneously lead to a negative trading interest and a subdued market environment (FICCI, 2020; Somwanshi, 2021). It orders to evade the situation where government becomes the only buyer of wheat from farmers, it is important to encourage agricultural market reforms and explore digital avenues to connect farmers to markets. Enhancing farm-to-market linkages is critical for augmenting farmers' income. Given the importance of horticulture in agricultural diversification and Indian agri-exports, it is also important to facilitate forward linkages so as to connect the producers with processors and exporters (Kumar et. al., 2020). This will not only minimise monetary losses on part of the producers but also ensure uninterrupted supply of raw material to the processors and benefit the overall food system by minimising wastage of produce.

2. **Food Processing Sector**

The impact of COVID-19 on the food processing sector emanates partly from the inconsistencies in the agriculture value chain and partly on its own account. With the announcement of Lockdown 3.0, partial relaxations were allowed in selected districts after their classification into 'red', 'orange', and 'green' districts based on Corona risk profiling (Business Standard, 2020). Estimates show that red and orange zones, with most restrictions in place, accounted for 42–46% of the average output of

8 major states (CRISIL, 2020). Therefore, partial relaxations continued to be a hindrance to supply chains, transportation, and logistics. The most evident bottleneck faced by the sector is the constraint on movement of agricultural produces from the farm or the Agricultural Produce Market Committee (APMC) *mandis* to the processing units. Apart from facing the difficulty in sourcing raw material, the food processing sector is also confronting labour shortage. This has not only impacted processing and packaging activities but also cargo handling at ports, thereby hampering exports of the sector. Hence, unless the entire supply chain is unlocked, the impact of improved economic activity will be subdued. Other than supply volatility, other factors contributing to the hardships of the sector include uncertain consumer demand and trade restrictions (Manepalli & Nagvenkar, 2020).

Given all these hindrances, the National Restaurants Association of India (NRAI) predicted an estimated loss of INR 800,000 million (USD 11,429 million) for the Food and Beverage industry by the end of May 2020 (Kumar, 2020). In order to evaluate the impact of the current pandemic on the food processing sector across Indian states we quantify the impact that the above stated loss will yield in terms of major macroeconomic indicators. The results are presented below:

Results:

Similar to the previous scenario, the impact analysis is presented in terms of the short run impact and the revival period for each macroeconomic variable.

1. **Output and Employment**

Table 4.16 presents the short run impact of the pandemic on the FPI in terms of Output and Employment at the national level as well as the state level. The top eight states that were impacted the most are listed in the table.

a. Short run Impact

At the national level, the impact on output of the industry marginally exceeds the impact on its employment. However, at the state level, the impact varies within and across the two variables. Not only the states of Karnataka, Andhra Pradesh, and West Bengal report the maximum loss in

Table 4.16 Short run impact in terms of output and employment of FPI (2020) (in %)

Sr. no	*State*	*% Impact on Output*	*State*	*% Impact on Employment*
	All India	−2.05	All India	−1.44
1	Kerala	−3.07	Karnataka	−3.89
2	Uttar Pradesh	−2.50	Andhra Pradesh	−3.49
3	Andhra Pradesh	−2.46	West Bengal	−3.29
4	Assam	−2.40	Kerala	−2.63
5	Punjab	−2.35	Uttar Pradesh	−2.11
6	West Bengal	−2.15	Haryana	−1.44
7	Karnataka	−1.89	Punjab	−1.27
8	Tamil Nadu	−1.87	Tamil Nadu	−0.61

Source Results from the model

employment in the country, the extent of loss in employment exceeds the impact in terms of their respective industry's output. For all other states mentioned in Table 4.16, the impact on output exceeds the impact on employment. For states like Punjab and Assam, which have a relatively lower share in the national FPI, a loss in output and employment of the extent comparable to bigger states can translate into a huge setback for the FPI in these states.

b. Revival of Output and Employment

Table 4.17 indicates the number of years that different states take to return to their baseline value of Output and Employment.

The states which show the quickest recovery in terms of both output and employment are Kerala and Uttar Pradesh. The performance of Kerala is particularly impressive given that the state experienced the maximum impact in terms of output. Andhra Pradesh takes a little longer and is able to return to their baseline value of output and employment in 2–3 years. Tamil Nadu, Haryana, West Bengal and Karnataka see their employment being revived within 3 years however the revival of output takes more than three years. Of all the states mentioned in Table 4.16, Punjab takes the maximum time for recovery of both its output and employment.

Table 4.17 Number of years required to return to baseline

Number of years required	*Key states-Output*	*Key states-Employment*
1 year	Kerala Uttar Pradesh	Kerala Uttar Pradesh
2–3 years	Andhra Pradesh	Andhra Pradesh Tamil Nadu Haryana West Bengal Karnataka
Greater than 3 years	Tamil Nadu West Bengal Assam Karnataka Punjab	Punjab

Source Results from the model

2. **Trade**

Table 4.18 shows the short run impact on the trade of the FPI across the top five states and the national level.

a. Short run Impact

At the national level, the dip in imports is greater than that of exports. At the state level, however, for all five states that experience the greatest negative impact in terms of exports, the extent of the negative deviation from their respective baseline values is greater for exports than imports.

Table 4.18 Short run impact in terms of trade of FPI (2020) (in %)

Sr. no	*State*	*% Impact on Exports*	*State*	*% Impact on Imports*
	All India	−0.15	All India	−0.32
1	Kerala	−2.48	Kerala	−1.65
2	Uttar Pradesh	−1.08	Uttar Pradesh	−0.68
3	West Bengal	−0.75	Karnataka	−0.42
4	Gujarat	−0.51	Haryana	−0.34
5	Assam	−0.36	West Bengal	−0.21

Source Results from the model

b. Revival of Trade

Table 4.19 indicates the number of years that the states mentioned in Table 4.18 take to return to their baseline value of exports and imports.

For Kerala and Uttar Pradesh, the time taken for revival of both exports and imports remains the same, with the former reviving its trade within 1 year whereas the latter takes 2–3 years for the same. West Bengal and Assam take the longest to get their exports back to the baseline level. In case of imports, Karnataka is another state that shows prompt revival. Haryana's imports take 2–3 years to return to the baseline value while West Bengal takes the longest for the same.

Remarks:

Upon the sudden announcement of the lockdown, grocery stores and supermarkets witnessed panic buying among consumers. As a result, processed food companies ramped up production and benefitted from the same. However, this benefit was rather short lived. With the extension of the lockdown, regulations limiting store operations as well as disruptions in logistics and labour movement led to low inventory and sales (The Hindu, 2020).

With the traditional offline sales channels cut off, semi-urban and urban informal operations and small and medium enterprises (SMEs) which carry out much of the tertiary activity related to the agri-food sector suffered greatly in terms of both employment and economic viability. These enterprises facilitate post-harvest handling and processing of agricultural produce. Ensuring agro-processing SMEs' access to reasonable and smooth credit lines from banks, especially during the crop

Table 4.19 Number of years required to return to baseline

Number of years required	*Key states- Exports*	*Key states- Imports*
1 year	Kerala	Kerala Karnataka
2–3 years	Uttar Pradesh Gujarat	Uttar Pradesh Haryana
Greater than 3 years	West Bengal Assam	West Bengal

Source Results from the model

season, will help them to manage the crisis and connect directly with farmers, even after the crisis (Kumar et. al., 2020).

The government is hopeful that the agricultural sector will help cushion the impact of the pandemic on the overall economy of the country and the hope of the agricultural sector lies in its exports. Looking at similar disruptions of agri-supply chains and production systems in competing countries with harder COVID impact, APEDA expects that the crisis will open newer prospects for Indian agri-exports. Accordingly, the government has identified major agricultural and processed food products which are seen as emerging opportunities for India due to disruption of export from the EU, US, and China (APEDA, 2020c).

However, agricultural exports can hardly sustain without a robust and competitive processing base. The lockdown added to the woes of an already inefficient supply chain as several important linkages came to a standstill. While transport bottlenecks prevented processing units from acquiring adequate raw materials, complete restriction on manufacturing units that provide packaging and labelling material further accentuated the industry's problems. Above all, for a labour intensive sector like the FPI, labour scarcity became the biggest handicap. Other impediments included the facilities and turnaround time at the port of exit (APEDA, 2020c).

4.6 Conclusion

This chapter analysed recent government initiatives in the Agriculture and Food Processing Sector, at both the national and sub-national levels, using the E3 India model, to draw insights about the feasibility and effectiveness of these policies. The results took into account the current status of the states and their respective sectors to comment on what can be expected in the future from these sectors.

With respect to the food processing sector, the analysis draws attention to the need for prioritising investment in infrastructure and harmonising the supply chain for the overall development of the sector. The potential of the FPI to accelerate country's structural transformation is also highlighted. The study concludes that without devoting policy attention and public resources towards skill development, capacity building, and improving access to credit and international market, India's FPI will not be able to take advantage of the emerging opportunities from changing consumer preferences in the wake of rapid urbanisation and demographic shifts. **Regional scenarios suggest that Maharashtra's FPI can gain significantly by devoting exclusive policy attention towards ramping up its exports and keeping its emissions in check**. UP and Rajasthan, on the other hand, are in need of deep rooted structural changes. **While the Uttar Pradesh Agricultural Export Policy 2019 has outlined an ambitious plan for creating a conducive export environment, success of the policy lies in its effective implementation.**

Analysis of the COVID-19 scenarios suggests that while the COVID-19 crisis has exposed the vulnerability of India's agricultural sector, it may have paved the way for something that has been due for very long, farm mechanisation of the sector. Having suffered at the helm of labour scarcity, more and more farmers are expected to invest in some form of mechanised solutions of varying intensity depending upon their capacity. However, the losses induced due to the pandemic have greatly affected their liquidity. In order to enable farmers to make this switch, the government has a huge responsibility to shoulder. Offering easy access to credit and ensuring availability of machines in local markets should be the top priorities of all states.

The results of the national and regional scenarios discussed earlier do not account for the pandemic induced losses imposed upon the agriculture and food processing sectors. Accommodating for the loss implies that the policy targets may need to be revisited. For the food processing sector to enhance its production capacity by the magnitude envisaged in the national food processing scenario, huge contribution will be required from the major states with food processing potential. However, looking at the revival trend among these key states, we can say that achieving this target by 2026 seems ambitious, and meeting this target can be expected to be delayed by at least 2 years until the output of some of the important states revive. Part of the reason for the slow revival of these states lies in the sluggish pace of infrastructure and technology upgradation that the sector has witnessed in the past. In case of the Agriculture Export Policy 2018, we believe that the country still possesses the potential to meet its target, largely because India's agricultural exports are currently below its full potential and states are still in the process of finalising their respective plan of action to align with the national policy target. Given that the government has been able to identify new export opportunities in the wake of the pandemic and has also shortlisted the destinations for deeper penetration, meeting the target for AEP 2018 entirely depends on the ability of the government to capitalise upon the opportunities it has identified. Nevertheless, we do not expect the agri-export basket to witness any significant increase in the share of processed food products, at least by 2022.

Overall, this study is in conformity with the literature in recognising the major factors that have prevented the Indian agriculture sector from performing at its optimal potential. Some of these factors include fragmented landholding, supply–demand mismatch, limited access to finance and institutional credit, a subsidy-driven market, poor implementation mix of support programmes, inefficiencies associated with subsidy disbursal, price distortions, and skill gaps (PWC-FICCI, 2019). Moreover, the chapter provides quantitative evidence to prove that without addressing these issues, the country does not stand to reap any significant or sustainable benefits from simply meeting output or export targets. Fortunately, there has been a major shift in the policy focus away from this traditional policy orientation and the major policies discussed in this chapter are a step in the right direction. The success of these policies in transforming Indian agriculture sector therefore depends on whether sufficient effort is devoted to their efficient implementation or not.

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CHAPTER 5

Importance of Capital Goods Sector: An Application of E3-INDIA Model

Priyam Sengupta, Shraddha Shrivastava, and Kakali Mukhopadhyay

5.1 Introduction

With its potential of driving industrialisation and economic development, the Indian Capital Goods (CG) sector holds strategic importance in steering the country towards achieving its goal of becoming a USD five trillion economy by 2025. Strengthening the domestic CG sector can not only boost manufacturing activity by providing critical inputs, but can also go a long way in generating employment as well as making the nation self-reliant. The Ministry of Commerce and Industry has defined

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CG as "*any plant, machinery, equipment or accessories required for manufacture or production, either directly or indirectly, of goods or for rendering services, including those required for replacement, modernization, technological upgradation or expansion*" (Ministry of Commerce & Industry, 2017). The major sub-sectors that constitute the CG sector include: *Machine Tools, Textile Machinery, Earthmoving and Mining Machinery, Heavy Electrical Equipment, Plastic Machinery, Process Plant Equipment, Dies, Moulds and Press Tools, Printing and Packaging Machinery, Metallurgy Machinery and Food Processing Machinery* (Department of Heavy Industry, 2016). Image 5.1 indicates the spread of major CG sub-sectors across India.

The CG sector has a robust multiplier effect and strong bearing on the growth of the user industries as it provides critical inputs, i.e. machinery and equipment, to these industries. The Indian CG industry contributes 12% to the total manufacturing activity which translates to about 1.8% of GDP (NSDC, 2013). The sector also provides direct employment to nearly 1.4 million people and indirect employment to almost 7 million people (Department of Heavy Industry, 2016). The CG sub-sectors are therefore catalysts for capacity building in numerous sectors such as infrastructure, power, mining, oil and gas, iron and steel, automotive and consumer durables (Invest India, 2020). In the heavy engineering and machine tools segment, the textile machinery and construction equipment industries are the largest industries, expected to reach a market size of USD 5.2 billion and USD 5 billion by 2021, respectively. In the light engineering sector, India became the second largest casting producer in the world by overtaking USA in 2017 by achieving 11 million tonnes of casting manufacturing in 2017. The forging industry is also one of the largest sectors within the light engineering segment that achieved a turnover of USD 5.43 billion in 2018 (IBEF, 2019).

In the Heavy Electricals segment, the Turbines and generators sector has production turnover of USD 6.6 billion in 2018 which is expected to reach USD 13.4 billion in 2022. The total production of the electrical equipment industry was USD 27.3 billion in 2017–2018, contributing 8% to the manufacturing sector and 1.5% to the national GDP while providing direct and indirect employment for 1.5 million people (IBEF, 2019). India is also a major exporter of electrical equipment, with exports registering a CAGR of 13.7%, from USD 5.3 billion in 2013–2014 to USD 8.9 billion in 2017–2018. The major export markets are USA, UAE, Germany and UK predominantly for products such as switchgear

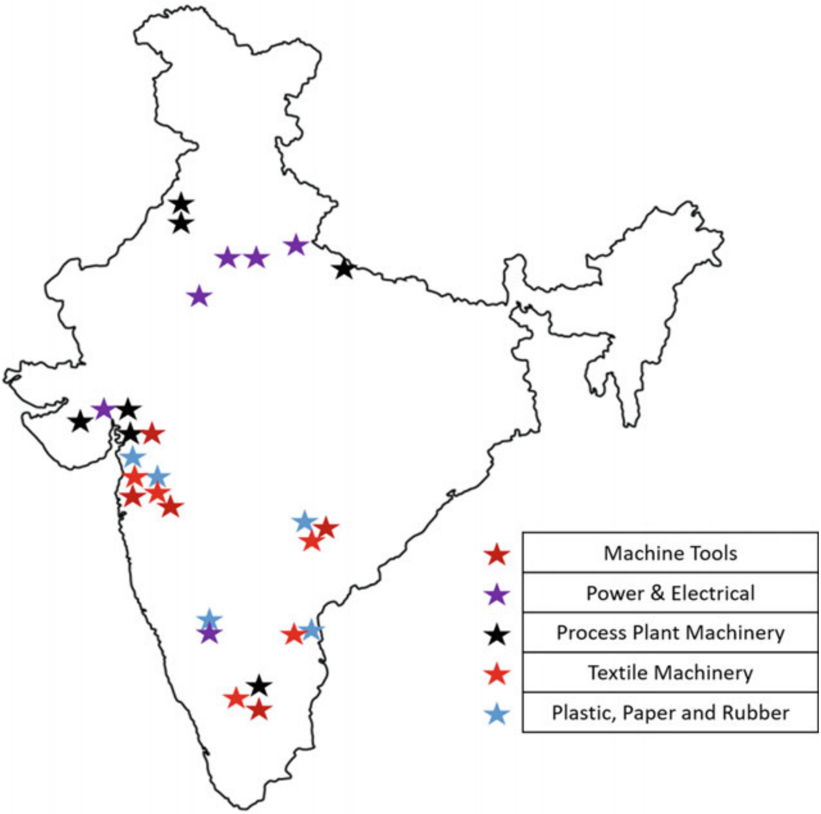

Image 5.1 Spread of major capital goods sub-sectors across India (*Source* Adapted from Capital Goods Skill Council of India [2020])

and control gear, transformers and parts, industrial electronics, cables, transmission line towers, conductors and rotating machines (motors, AC generators and generating sets) (EEPC India, 2019).

Over the last decade, the Indian CG sector has grown by almost 2.75 times. However, **major portion of the CG demand in India is met through imports**. India imported machinery worth more than USD 30 billion in 2015, making it the fourth-largest import category. Additionally, the contribution of CG sector to GDP lags far behind other industrialised nations like China and Germany, and less than one-tenth of its sales are directed towards exports (Agrawal & Sengupta, 2017). Yet, given India's growing demand for CG, there may be signs of reversal of these trends in near future through accelerated economic reforms. Based on the push under the "Make in India" campaign and the trends in key end-use sectors like power, mining, aerospace & defence manufacturing, etc., there are multiple growth opportunities on the horizon for the domestic CG sector to take leverage of. Catering to these new opportunities and simultaneously lowering barriers for domestic and foreign investment can promote domestic capacity as well as competitiveness (Agrawal & Sengupta, 2017). Major policies pertaining to infrastructure development like Housing for All by 2022, Pradhan Mantri Gram Sadak Yojana (Prime Minister's Rural Road Scheme) and Atal Mission for Rejuvenation and Urban Transformation (AMRUT) have provided a major boost to one of the most capital-intensive sector, the cement industry. India is the second largest cement producer in the world with 8% of global capacity. It is also one of the largest employers in the manufacturing sector, employing about 20,000 people downstream per million tonnes of cement produced (IBEF, 2020). South India constitutes approximately 35% of total cement production in India, followed by 20.4% in North and 18.4% in the East (CMA, 2020).

Similarly, several **other favourable government initiatives have supported the growth of the electrical equipment industry**. These include delicensing—allowing 100% foreign direct investment (FDI) through the automatic route, reduced taxes and custom duties as well as export incentives through the export promotion capital goods (EPCG) schemes. There are 15 Special Economic Zones (SEZs) across the country for engineering goods sector, including electrical equipment machinery. Furthermore, **the government is also planning to establish special electrical equipment industry clusters across the country in order to develop infrastructure especially catering the sector** (EEPC India, 2019).

While all these policies have been instrumental in steering the country towards industrial and economic growth, their implications have been different across different states. Depending on various factors like availability of basic ingredients, local demand, resource endowments and human resource, different products are produced in different parts of the country. While the coastal states have better opportunity to access overseas markets compared to landlocked states, Eastern states like Jharkhand

and Odisha have maximum mineral deposits. Similarly, states like Maharashtra and Karnataka have comparative edge in terms of availability of skilled human resource and better technical know-how.

Hence, while implementing any policy at the national level, the Government has to remain extremely cautious about its implications across different states. The state governments should always be consulted before embarking on any new initiative, since most of the states do not have any clear-cut state-level CG Policy yet. In this context, **this chapter intends to highlight the regional implications of recent national-level government initiatives in the CG sector using E3-India model which has been described elaborately in** Chapter 2. Given the broad base of the CG sector, spanning over 10 sub-sectors, each of which is produced unequally across different states with varying degree of technological innovation and incentive scheme, **the regional framework offered by the E3-India model serves as the most sophisticated policy evaluation tool for this purpose**. The following section outlines the methodology followed for scenario development for each policy considered in this chapter while Sect. 5.3 highlights the results and the accompanying discussion. Section 5.4 provides an extension to Sect. 5.3, by demonstrating the combined impact of all the policies for which the results have been presented in the previous section. Section 5.5 highlights the possible implications of the current COVID-19 pandemic on the CG Sector. Finally, Sect. 5.6 concludes with some broad policy recommendations in Sect. 5.7.

5.2 Scenario Development

This section outlines the methodology followed for the development of scenarios for analysing government policies relating to the CG sector. The policies included in this chapter are national-level policies, from which six scenarios are derived based on policy targets in terms of one or more of the following macroeconomic parameters: Output, Investment, Employment and Export. The policy shocks were introduced in the E3 model through two sectors, viz. Electrical Engineering and Instrument, and

Other Manufacturing. While the former accounts for the largest sub-sector of the CG sector, i.e. the Heavy Electrical Equipment sector, the latter represents the remaining 9 sub-sectors.[1]

A two-step adjustment process was then undertaken to attune the stated policy targets to suit the requirements of the E3-India model. First of all, each policy target was split between these two sectors, with nearly 60% attributable to the Electrical Engineering and Instrument sector while the rest was assigned to the Other Manufacturing sector.[2] From these national-level targets for each variable, the next step was to derive state-level policy targets as per the following rule:

For output or investment targets: The state-wise devolution of the national target was done in accordance with the share of each state in the Value of Gross Output in 'Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus' (NIC code: 271) for Electrical Engineering & Instrument sector and 'Manufacture of machinery and equipment n.e.c.' (NIC code: 28) for Other Manufacturing sector, for the year 2017–2018, as reported by the Annual Survey of Industries (ASI). Top 9 states which together constituted 80–90% share were selected for analysing the impact of the respective policy. The state-wise share for all output and investment-oriented scenarios is documented in Table 5.13 in the appendix.

For employment targets: The state-wise devolution of the national target was done in accordance with the share of each state in the 'Total Persons Engaged' in 'Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus' (NIC code: 271) for Electrical Engineering and Instrument variable and 'Manufacture of machinery and equipment n.e.c.' (NIC code: 28) for Other Manufacturing variable, for the year 2017–2018, as reported by the Annual Survey of Industries (ASI). Top 11 states which together constituted 80–90% share were shortlisted for analysing the impact of the respective policy. Table 5.14 in the appendix documents the state-wise share for the employment-oriented scenarios.

[1] Other Manufacturing Sector: Machine tools, Textile machinery, Earthmoving and mining machinery, Plastic machinery, Process plant equipment, Dies, moulds and press tools, Printing machinery, Metallurgical Machinery and Food processing machinery [Capital goods sector = Electrical Engg. & Instrument + Other Manufacturing].

[2] In accordance with the share of each sub-sector in the Capital Goods Total Production (2014–2015), as stated in the National Capital Goods Policy, 2016.

For export targets: The state-wise devolution of the national target was done in accordance with the share of each state in the 'Product Exports' (E3-India code: QRX) for export-oriented targets, for the year 2020, as reported under the BAU scenario of the E3-India model for both variables individually. The trade data in the E3-India model has been taken from the Directorate General of Commercial Intelligence and Statistics (DGCIS) database and thus serves as a reliable source for this scenario. Top 10 states which together constituted 80–90% share were shortlisted for analysing the impact of the respective policy. Table 5.15 in the appendix documents the corresponding share for export-oriented scenarios.

With this two-step adjustment process, the state-level sectoral targets were achieved and the relevant scenarios were introduced in the E3-India model for each policy target. Figure 5.1 gives an overview of this scenario development process.

The policies considered for this chapter and the scenarios drawn from them are explained below.

5.2.1 National Capital Goods Policy (2016)

The first policy reviewed in this chapter is the National Capital Goods Policy, 2016. This policy was formulated with the vision to increase the share of CG contribution to 20% of total manufacturing activity by 2025. This policy was devised to complement the National Manufacturing Policy, 2011 which aimed to increase the share of manufacturing in Gross Value Added (GVA) to 25% and create 100 million jobs by 2022 (Department of Heavy Industry, 2016).

The National Capital Goods Policy is by far the most comprehensive and significant policy initiative taken by the government regarding this sector. It addresses a wide range of issues affecting the CG sector including, but not limited to, domestic demand creation, exports, technology depth, cost competitiveness and skill availability, simultaneously highlighting and elaborating sub-sector specific issues as well (Department of Heavy Industry, 2016).

This policy therefore intends to boost the CG sector by facilitating an enabling environment for the growth of CG and guaranteeing sustained incentive for domestic manufacturers to meet domestic as well as export

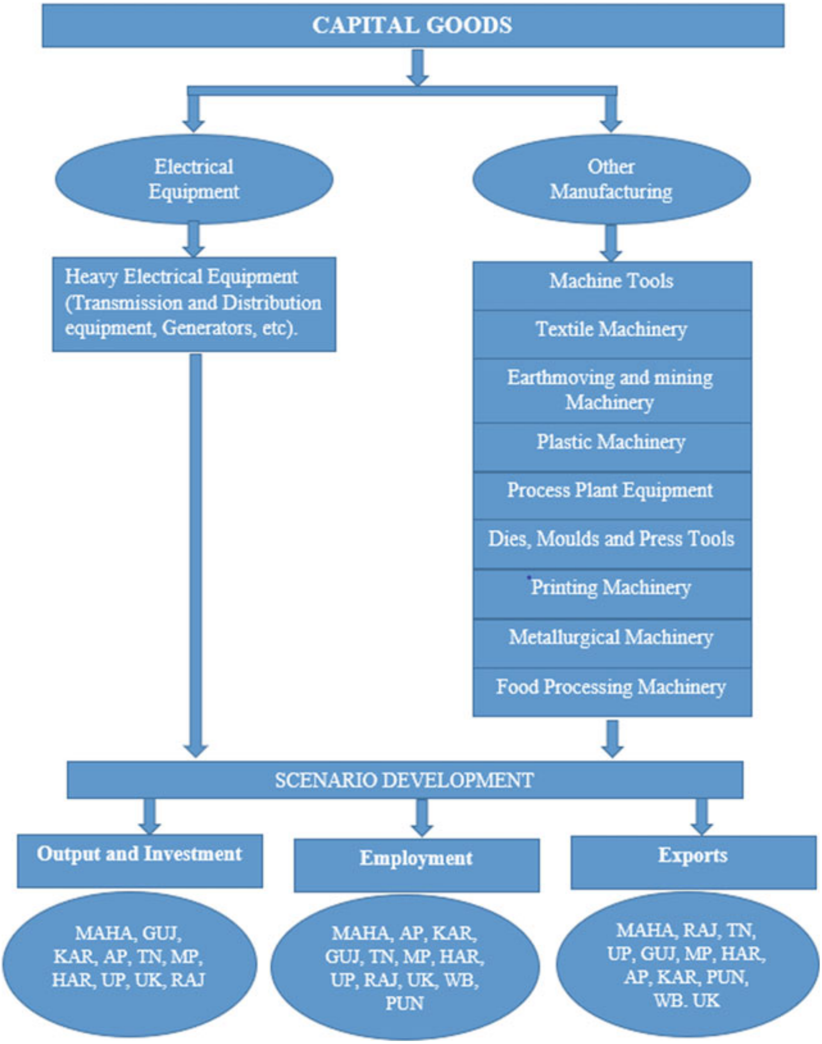

Fig. 5.1 Overview of scenario development (*Source* Prepared by Authors)

market demand, thereby making the sector globally competitive as well as dynamic. In order to meet this end, the policy outlines well-defined targets to be attained by 2025. These targets form the foundation of our policy analysis using the E3-India model. Three policy targets relating to output, employment and export are considered as three separate scenarios under this policy. Other objectives outlined by the policy include increasing domestic market share, improving skill availability and technology depth, endorsing relevant standards and promoting SMEs. The three scenarios considered for the purpose of gauging the impact of this policy are as follows:

5.2.1.1 Scenario 1.1: Increase Total Production

The National Capital Goods Policy intends to achieve total production of CG in excess of around USD 107 billion (INR 7500 billion) by 2025. In 2014–2015, industry's total production stood at around USD 33 billion (INR 2300 billion). Hence, the additional production to be attained by 2025 stands at USD 74 billion (INR 5200 billion).

The corresponding state-level targets were calculated from the shares of the respective sectors mentioned in Table 5.13 in the appendix. The respective state-level targets are mentioned in Table 5.1.

Table 5.1 State level targets for Scenario 1.1 (2016–2025)

	Electrical Engineering and Instrument		*Other manufacturing*	
Sr. no	*State*	*Output target (USD billion)*	*State*	*Output target (USD billion)*
1	Maharashtra	10.8	Maharashtra	7.9
2	Gujarat	5.08	Tamil Nadu	5.85
3	Karnataka	5.02	Gujarat	4.13
4	Andhra Pradesh	3.48	Karnataka	2.52
5	Tamil Nadu	3.9	Haryana	2.08
6	Madhya Pradesh	2.86	Punjab	1.41
7	Haryana	2.07	Uttar Pradesh	1.22
8	Uttar Pradesh	1.78	Uttarakhand	1.08
9	Uttarakhand	1.50	Rajasthan	0.83
	Total	36.6	Total	27.05

Source Authors' calculations

5.2.1.2 Scenario 1.2: Increase Employment

The National Capital Goods Policy aims to provide additional employment to over 21 million people by 2025 through the CG sector. The respective state-level targets are mentioned in Table 5.2 using the state-wise shares for the respective sectors given in Table 5.14 in the appendix.

Table 5.2 State level targets for Scenario 1.2 (2016–2025)

	Electrical Engineering and Instrument		*Other manufacturing*	
Sr. no	*State*	*Employment target (thousands)*	*State*	*Employment target (thousands)*
1	Maharashtra	2417	Maharashtra	1822
2	Andhra Pradesh	1718	Tamil Nadu	1528
3	Karnataka	1409	Gujarat	1492
4	Gujarat	1295	Karnataka	674
5	Tamil Nadu	1251	Haryana	517
6	Madhya Pradesh	755	Punjab	472
7	Haryana	725	Uttar Pradesh	464
8	Uttar Pradesh	624	Andhra Pradesh	337
9	Rajasthan	318	Uttarakhand	269
10	Uttarakhand	315	Rajasthan	210
11	West Bengal	306	West Bengal	187
	Total	10,665	Total	7853

Source Authors' calculations

5.2.1.3 Scenario 1.3: Increase Exports

With respect to exports, the policy intends to increase the share of exports to 40% of total production of CG, or equivalently to USD 43 billion (INR 3000 billion), by 2025, making India a net exporter of CG. In the year 2014–2015, industry exports amounted to nearly USD 9 billion (INR 610 billion). Therefore, the amount of additional exports to be achieved by 2025 stands at about USD 34 billion (INR 2390 billion). The respective state-level targets are mentioned in Table 5.3 using the state-wise export shares for respective sectors mentioned in the appendix.

Table 5.3 State level targets for Scenario 1.3 (2016–2025)

	Electrical Engineering and Instrument		*Other manufacturing*	
Sr. no	*State*	*Export target (USD billion)*	*State*	*Export target (USD billion)*
1	Maharashtra	5.09	Maharashtra	4.65
2	Uttarakhand	1.94	Gujarat	2.03
3	Karnataka	1.71	Tamil Nadu	2.09
4	Rajasthan	1.40	Karnataka	1.75
5	Tamil Nadu	1.38	Punjab	0.48
6	Uttar Pradesh	1.35	Haryana	0.48
7	Gujarat	1.16	Uttar Pradesh	0.41
8	Madhya Pradesh	0.99	Rajasthan	0.12
9	Haryana	0.91	West Bengal	0.36
10	Andhra Pradesh	0.66	Uttarakhand	0.34
	Total	16.59	Total	12.70

Source Authors' calculations

5.2.2 National Steel Policy (2017)

India is the second largest steel-producing country in the world. It is strongly integrated with the rest of the economy such that one unit of output of steel generates 1.4 times output and 6.8 times employment in the rest of the economy (PWC, 2019). Due to its large application in various sectors of the economy, the intermediate demand for steel remains very high. The largest user of steel is the construction sector which accounts for nearly 60% of the total steel demand. This is followed by the automobile industry. Both these industries are expected to become the third largest in the world by 2025 and 2026, respectively. In order to meet the requirement of these sectors adequately, India will have to step up its steel-producing capacity significantly. In this context, the recent trends in export and import of finished steel seem encouraging. Figure 5.2 depicts India's export and imports in finished steel over the last few years.

As we can see from Fig. 5.2, India's import dependence on steel has steadily decreased over the years, due to various government initiatives in order to become more self-reliant in the steel sector. One of the initiatives was the anti-dumping duty as India was victim of cheap imports of steel especially from China (Saraswat & Bansal, 2019).

However, while the Indian steel production has been growing at an impressive rate in the recent past, the gap between India's total steel

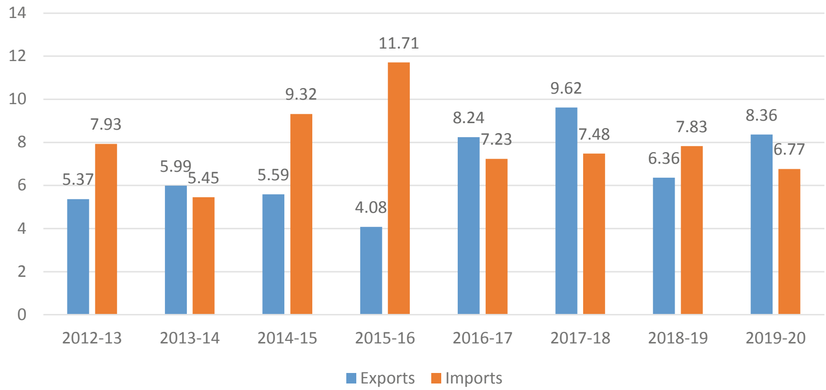

Fig. 5.2 Export and import of finished steel (2012–2020) (in Million Tonnes) (*Source* GOI [2017, 2020])

production and that of China, world's largest steel producer, is still substantial (WSA, 2020). Moreover, India has not been able to achieve cost-effectiveness in the production of finished steel. In 2016, India was ranked second highest in terms of cost of conversion of iron ore to steel. NITI Aayog, India's leading federal think tank, has estimated that the largest share of the total cost is constituted by cost of finance, followed by logistics and infrastructure, equivalent to nearly USD 30–35/ton and USD 25–30/ton higher than the world average, respectively (Saraswat & Bansal, 2019).

Acknowledging these bottlenecks, the National Steel Policy (NSP), 2017 was formulated which has put forth a roadmap to further steer the steel industry by intending to achieve 300 Million Tonnes (MT) of steel-making capacity by 2030 (Ministry of Steel, 2017). This translates into increasing the present capacity by roughly 2.5 times to meet the stated target (PIB, 2018).

Recognising the critical role of CG sector in achieving this ambitious target, the Ministry of Steel and Department of Public Enterprises, Government of India, along with Confederation of Indian Industry (CII) and MECON Limited (MECON) organised a Conclave on "Capital goods in steel sector: Manufacture in India" in Bhubaneswar, Odisha in October 2018. This Conclave was an initiative to enhance the indigenous capacity and capability building of CG in the steel sector that would transform India into a world class manufacturing hub (PIB, 2018). The investment targets stated under NSP 2017 serve as the scenarios for critically analysing the impacts of this policy. The two scenarios considered for this policy are as follows:

5.2.2.1 Scenario 2.1: Increase Domestic Investment

According to the Ministry of Steel, setting up of 300 MT steel capacity as envisaged under the NSP 2017 will require domestic investments of over USD 128 billion (PIB, 2018).

5.2.2.2 Scenario 2.2: Enhance Domestic Capacity

A major portion of the core equipment requirement of Indian Steel plants is import dependent. The Ministry of Steel has estimated that CG equipment worth USD 25 billion will have to be imported to meet the target set under NSP 2017 (PIB, 2018). Considering this as an opportunity to provide an impetus to Government of India's Make in India initiative, Ministry of Steel has urged global CG companies to set up manufacturing units in the country (The Economic Times, 2019).

This scenario analyses the impact of this policy assuming that the estimated CG import requirement is met domestically, which directly translates into an investment worth USD 25 billion in the domestic CG sector. Table 5.4 mentions the state-level investment targets for both these scenarios until 2030 using the state-wise investment shares shown in Table 5.13 in the appendix.

5.2.3 Indian Electrical Equipment Industry Mission Plan 2012–2022

The Indian Electrical Equipment Industry Mission Plan 2012–2022 was formulated with the ultimate objective of making India the preferred destination for electrical equipment production. This mission plan outlines the path for the Electrical Equipment Industry to enhance its preparedness and strengthen its competitiveness to meet the requirements of the most crucial component of industrial and economic development, the Power sector. This mission plan addresses issues relating to five critical areas of the industry: industry competitiveness, technology upgradation, skills development, exports and conversion of latent demand (Ministry of Heavy Industries & Public Enterprises, 2013). The mission plan also

Table 5.4 State level targets for Scenario 2.1 and 2.2 (2017–2030)

	Electrical Engineering and Instrument			*Other manufacturing*		
Sr. no	*State*	*Investment target (USD billion)*		*State*	*Investment target (USD billion)*	
		Scenario 2.1	*Scenario 2.2*		*Scenario 2.1*	*Scenario 2.2*
1	Maharashtra	16.75	3.35	Maharashtra	12.15	2.43
2	Gujarat	7.82	1.56	Tamil Nadu	8.99	1.80
3	Karnataka	7.73	1.55	Gujarat	6.36	1.27
4	Andhra Pradesh	5.36	1.07	Karnataka	3.88	0.78
5	Tamil Nadu	6.00	1.20	Haryana	3.20	0.64
6	Madhya Pradesh	4.40	0.88	Punjab	2.17	0.43
7	Haryana	3.19	0.64	Uttar Pradesh	1.88	0.38
8	Uttar Pradesh	2.75	0.55	Uttarakhand	1.67	0.33
9	Uttarakhand	2.30	0.46	Rajasthan	1.28	0.26
	Total	56.28	11.26	Total	41.59	8.32

Source Authors' calculations

specifies a target for capacity expansion, which will be utilised as a scenario for analysing the impact of this particular policy.

5.2.3.1 Scenario 3: Increase Output

The Indian Electrical Equipment Industry Mission Plan 2012–2022 aims to attain electrical equipment output worth USD 100 billion by 2022. In 2011–2012, industry's total production stood at around USD 25 billion. Hence, the additional production to be attained by 2022 stands at USD 75 billion.

As this policy pertains to the Electrical Equipment Industry specifically, the E3 sector used for this exercise is 'Electrical Engineering & Instrument' only. The corresponding state-level targets are presented in Table 5.5 using the state-wise output shares given in Table 5.13 in the appendix:

The results for all these policies are presented and discussed in the next section.

Table 5.5 State level targets for Scenario 3 (2012–2022)

Sr. no	*State*	*Output target (USD billion)*
1	Maharashtra	13.16
2	Gujarat	6.14
3	Karnataka	6.07
4	Andhra Pradesh	4.72
5	Tamil Nadu	4.21
6	Madhya Pradesh	3.46
7	Haryana	2.50
8	Uttar Pradesh	2.16
9	Uttarakhand	1.81
	Total	44.22

Source Authors' calculations

5.3 Results and Discussion

In this section, we analyse the results of the policies related to the CG sector discussed in the previous section using the E3-India model. The impact is evaluated in terms of three broad categories: first, we look at the macroeconomic impact of the policy at the national and regional level. Next, we look at the direct impact of the policy on the Electrical Engineering and Instrument and Other Manufacturing sectors. Finally, we look at the indirect impact of the policy, i.e. the impact that both these sectors yield on the other sectors of the economy. The variables selected for these impacts vary across scenarios depending on the orientation of the scenarios.

5.3.1 Results for the National Capital Goods Policy, 2016

5.3.1.1 Scenario 1.1

Policy impact across states is measured in terms of the performance of respective states across a number of indicator variables, which include the following:

1. **Macroeconomic Impact**

Figure 5.3 presents the macroeconomic impact of the policy in terms of Gross Disposable Income (GDI) on the top five states.

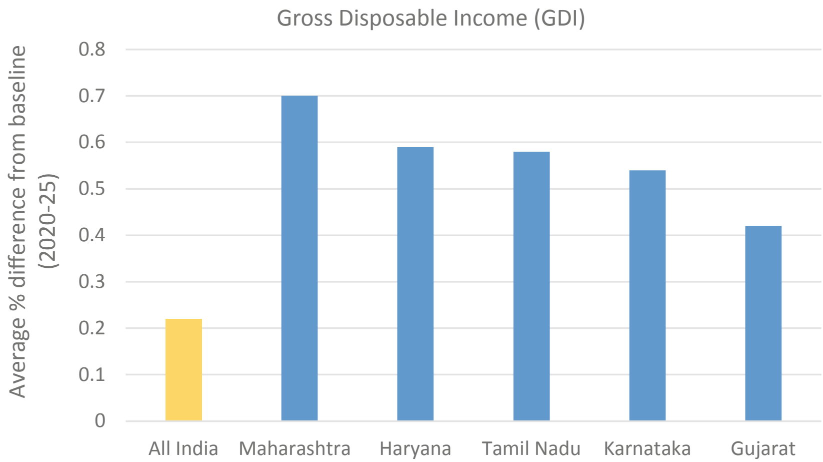

Fig. 5.3 Average % difference from baseline for GDI (2020–2025) (*Source* Results from the model)

The top five states with the maximum impact on their Regional Income are the leading manufacturing destinations of the country. Maharashtra and Tamil Nadu are the leading automobile manufacturing hubs, with Haryana catching up in terms of both automobile manufacturing as well as large-scale infrastructure development. Karnataka is one of the leading producers of crude steel and also possesses large number of manufacturing units across several domains. Finally, Gujarat is one of the few states in the country where the share of manufacturing in the state GDP exceeds both agriculture and services. At the national level, however, the impact remains minimal, resulting in an average increment of nearly 0.2% above baseline between 2020 and 2025.

2. **Direct Impact**

The direct impact of this scenario is measured in terms of trade and industry employment.

a. **Trade**

Table 5.6 presents the impact of higher output of the CG sector on

Table 5.6 Average % difference from baseline for trade (2020–2025)

Electrical Engineering and Instrument				*Other manufacturing*		
Sr. no		*Exports (%)*	*Imports (%)*		*Exports (%)*	*Imports (%)*
	All India	11.49	−1.13	All India	11.12	4.29
1	Gujarat	33.09	2.29	Maharashtra	25.10	8.13
2	Maharashtra	32.63	−6.56	Haryana	22.18	4.81
3	Haryana	14.57	−6.27	Gujarat	6.45	4.03
4	Andhra Pradesh	14.18	2.70	Uttarakhand	4.93	4.41
5	Madhya Pradesh	1.03	0.46	Karnataka	4.65	3.72

Source Results from the model

the exports and imports of the sector at the national and regional level.

The impact on exports at the national level is quite considerable for both the sectors. Currently, the Heavy Electrical Equipment sub-sector of the CG sector constitutes the largest share of CG exports as well as imports (Department of Heavy Industry, 2016). Therefore, the significant increase in exports in the Electrical Engineering and Instrument sector, coupled with a decline in the imports below the baseline value, can translate into a substantial boom for the country's trade balance.

At the regional level, we can observe that the major gain in terms of exports is concentrated in a very few states. In case of the Electrical Engineering and Instrument sector, the coastal states of Gujarat and Maharashtra stand to gain the most. Haryana's performance remains impressive in terms of both exports and imports. Andhra Pradesh, another coastal state, shows considerable impact while the performance of Madhya Pradesh remains incommensurate with its share in the national heavy electrical equipment industry. In case of the Other Manufacturing sector, Maharashtra and Haryana lead the way. Comparing the limited impact on the exports of Gujarat and Karnataka with their respective shares in the exports of the Other Manufacturing sector in Table 5.6 suggests that there are factors constraining the export performance of these states. Uttarakhand's performance highlights the potential of the state to emerge as a promising contributor to the sector's exports.

b. **Industry Employment**

The impact of this scenario on the employment of the Electrical Engineering and Instrument sector and the Other Manufacturing sector is presented in Fig. 5.4.

The CG sector is known to be labour intensive and the results in Fig. 5.4 suggest that the higher output of the sector under this scenario translates into higher employment. Even at the national level, the impact remains significant, reiterating the employment potential of both the sectors. The regional level impact provides insights into the respective capacity of different states to generate employment opportunities. Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Haryana, Uttarakhand and Maharashtra experience significant gains under both scenarios which emphasises the employment generation potential of these states across major subsectors of the CG sector. A non-target state which exhibited significant impact in terms of employment in the Electrical Engineering and Instrument sector was Jharkhand, for which the average growth from baseline employment over 2020–2025 was about 7%.

3. **Indirect Impact**

Table 5.7 presents the impact that increased output of the CG sector yields on the output of different sectors of the economy along with the states that experience the maximum impact, measured in terms of average percentage difference in output from baseline over 2020–2025.

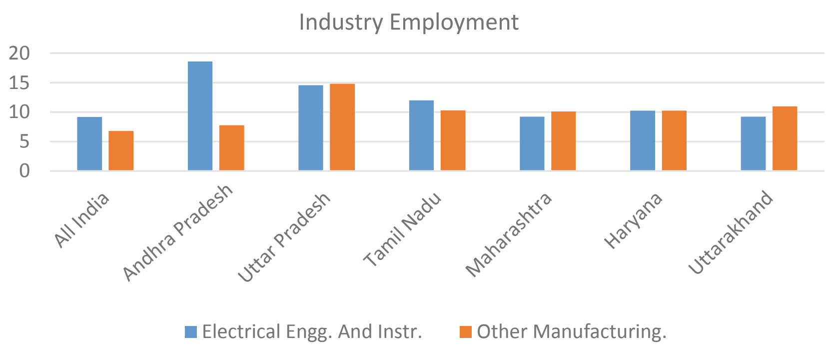

Fig. 5.4 Average % difference from baseline for industry employment (2020–2025) (*Source* Results from the model)

Table 5.7 Average % difference from baseline for Sectoral output (2020–2025)

Sr. no	*Sector*	*States*	*% range of difference from baseline*
1	Basic Metals	Maharashtra, Madhya Pradesh, Haryana	5–10
2	Metal Goods	Madhya Pradesh, Andhra Pradesh, Karnataka	9–15
3	Coal	Andhra Pradesh, Maharashtra, Tamil Nadu	20–25
4	Electricity Supply	Haryana, Uttar Pradesh, Maharashtra	21–28
5	Oil & Gas	Andhra Pradesh, Rajasthan, Tamil Nadu	25–35

Source Results from the model

Greater availability of CG by means of increased output of the sector provides a boost to the primary users of these goods. For instance, the output of Coal and Oil & Gas sectors increases significantly which can be attributed to the increased availability of Earthmoving and Mining Machinery. Similarly, Basic Metals and Metal Goods benefit from the increased output of metallurgical and machine tools, respectively. Finally, the increase in Electricity Supply can be attributed to the increased accessibility of Heavy Electrical Equipment. These are all the forward linkages that we have discussed above. However, another important point to be noted here is that all these sectors also constitute major inputs to the CG sector at several levels. While Basic Metals and Metal Goods constitute the primary inputs of the sector, Electricity is a major utility that supports the operation of the sector. Higher electricity in turn implies higher output of coal as the major source of electricity in India is still thermal based. Thus, these sectors benefit from backward linkages too.

These results play an instrumental role in highlighting the fact that an increased output of the CG sector is accompanied by an increase in the output of several other sectors most of which are emission-intensive. The E3-India model allows us to look at the Electricity Use of major industries as well as the CO_2 Emissions by different states in order to meet the increased output of a particular sector. The results for the same are presented in Fig. 5.5 with respect to the increased output of the CG sector.

Andhra Pradesh (which includes Telangana) shows the maximum increase in Electricity Use, followed by Uttarakhand and Haryana.

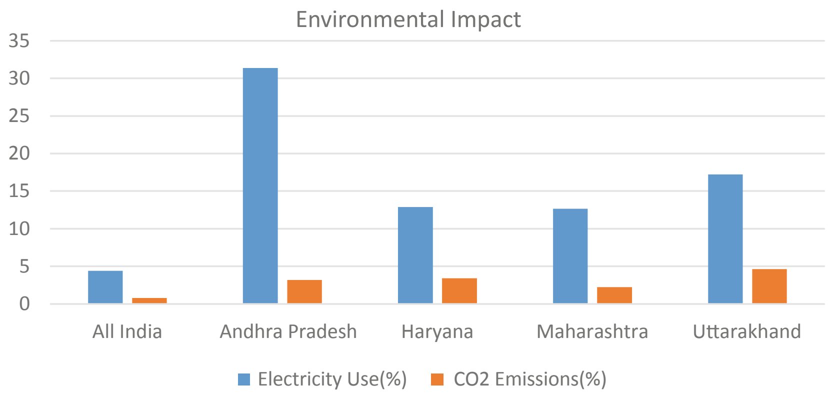

Fig. 5.5 Average % difference from baseline for electricity use and CO_2 emissions (2020–2025) (*Source* Results from the model)

However, in terms of CO_2 emissions, it is the emerging states of Uttarakhand and Haryana which experience the maximum impact. Therefore, it is important that regional policy attention is directed towards keeping emissions under control by promoting adoption of renewables and providing support for technology upgradation. Currently, significant challenges and gaps exist in adoption of high-productivity technologies across sub-sectors of the CG sector (Department of Heavy Industry, 2016).

5.3.1.2 Scenario 1.2

The macroeconomic impact of additional employment generation in the CG sector is measured through Gross Disposable Income (GDI). The results for the same are presented in Table 5.8.

Table 5.8 Average % difference from baseline for Gross Disposable Income (2020–2025)

Sr. no	*% range*	*States*
1	Less than 1%	Gujarat, Karnataka, Uttarakhand, Tamil Nadu, Haryana

Source Results from the model

The results in Table 5.8 indicate the states which will be at the forefront in terms of translating gains from increased employment in the

CG sector into regional income. The minimal increase across both these variables throw light upon the fact that the significant gap between the requirements of the industry and the existing skill set of the available labour pool restricts the eligibility for employment to a great extent. Acknowledging this fact, the policy proposes to upgrade existing training centres and set up 5 regional State-of-the-Art Greenfield Centres of Excellence for skill development of CG sector (Department of Heavy Industry, 2016). Successful implementation of this proposal is critical to avail the employment opportunities generated by capacity enhancement of the CG sector.

5.3.1.3 Scenario 1.3

The macroeconomic impact of additional exports of the CG sector is measured through GDP, while the direct impact of the same is gauged through Industry Output.

1. **Macroeconomic Impact**

The results for the macroeconomic impact of the scenario are presented in Fig. 5.6.

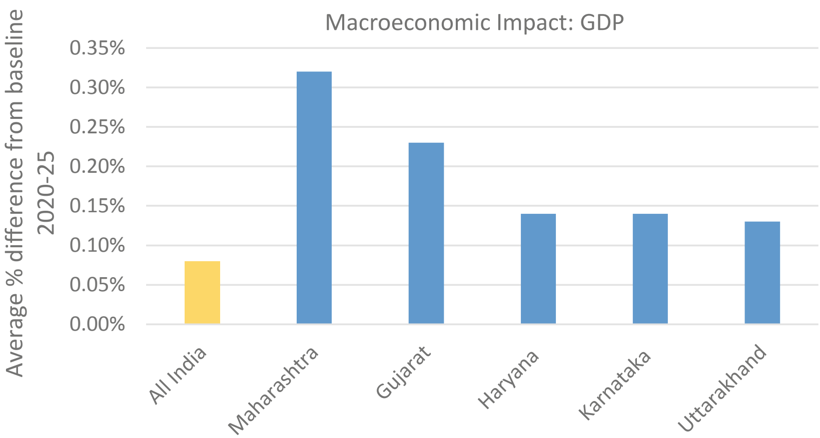

Fig. 5.6 Average % difference from baseline for GDP (2020–2025) (*Source* Results from the model)

The states that are able to benefit the most in terms of GDP are the coastal states of Maharashtra and Gujarat, which lead national exports across all the major sectors. The results also highlight the potential of the landlocked states of Haryana and Uttarakhand to emerge as major players in the export of CG.

2. **Direct Impact**

The direct impact of this particular scenario in terms of Industry Output is presented in Fig. 5.7.

The results in Fig. 5.7 are indicative of the states which are most capable of expanding their output to meet increased exports. While the top five states which exhibit this potential are all major players in the CG sector, the absence of states like Gujarat and Tamil Nadu is concerning. The average growth experienced by the Electrical Engineering and Instrument sector is almost 2.5 times the average growth of Other Manufacturing sector. This highlights the potential of the largest constituent of the CG export to enhance its capacity further and increase its contribution further in the CG export.

5.3.2 Results for the National Steel Policy, 2017

The macro-economic impact of this policy will be measured in terms of GDP and Gross Disposable Income (GDI). The direct impact will be evaluated through industry employment. Finally, in line with the policy's intention to contribute to the expansion of the steel sector, the impact of the policy on the same will be evaluated.

5.3.2.1 Scenario 2.1 and 2.2

Here we evaluate the impact of increased output of the CG sector to the extent of USD 128 billion by 2030 under Scenario 2.1 and the impact of enhanced domestic capacity of the sector to the extent of USD 25 billion by 2030 under Scenario 2.2. As Scenario 2.2 is an extension of Scenario 2.1, the results of this scenario should be interpreted as the additional impact that the states will experience, over and above what is reported in Scenario 2.1, i.e. if the entire investment in the CG sector under the National Steel Policy is made domestically.

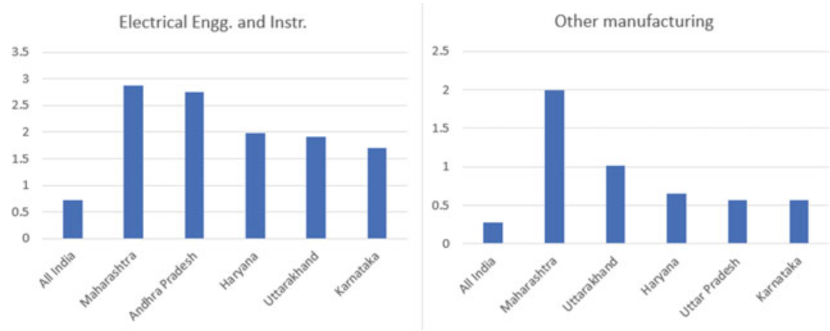

Fig. 5.7 Average % difference from baseline for Industry Output (2020–2025) (*Source* Results from the model)

1. **Macroeconomic Impact**

Figure 5.8 summarises the macroeconomic impact of increased output and capacity enhancement of the CG sector on the overall economy of the top five states in terms of GDP.

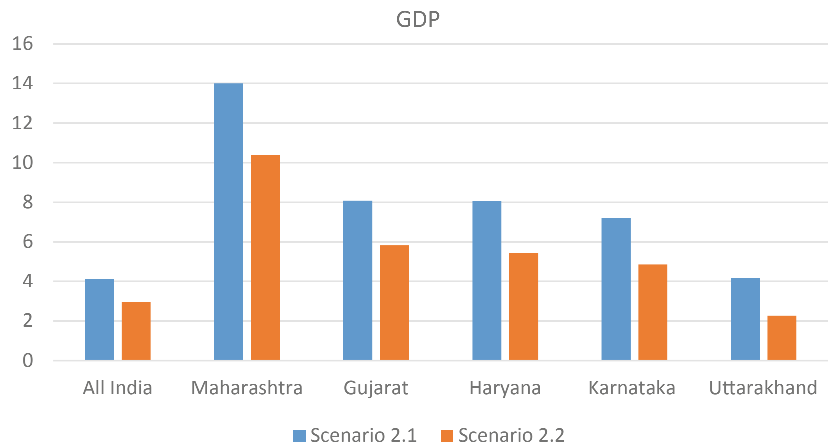

Fig. 5.8 Average % difference from baseline for GDP (2020–2030) (*Source* Results from the model)

All these states are strong players in either infrastructure development or manufacturing or even both. Maharashtra experiences the maximum impact in terms of both variables. This growth is driven by both manufacturing and infrastructure development. The same is the case with Gujarat and Haryana, both of which have witnessed considerable growth in both these sectors. Other states that experience significant impact include Karnataka and Uttarakhand. The performance of both these states can be explained in terms of their strong manufacturing potential. Two non-target states that showed significant impact in terms of GDP were Chhattisgarh and Odisha, experiencing an average growth of nearly 1.5% and 1.3%, respectively. Although minimal, these states made it to the top ten states in terms of GDP.

The results for Scenario 2.2, especially in the case of GDP, suggest that additional investment in the domestic CG sector can add significantly to the existing capacity of these states.

2. Direct Impact

Figure 5.9 outlines the direct impact of Scenario 2.1 and 2.2 in terms of industry employment in the Electrical Engineering and Instrument and the Other Manufacturing sectors.

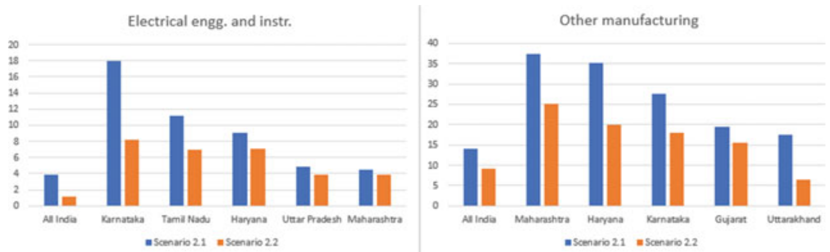

Fig. 5.9 Average % difference from baseline for industry employment (2020–2030) (*Source* Results from the model)

The CG sector is a labour-intensive sector and its potential to drive employment in the manufacturing segment is evident from the results shown in Fig. 5.9. In case of the Electrical Engineering and Instrument sector, Karnataka gains the most in terms of employment. The other nine sub-sectors of the CG sector collectively represented by the Other Manufacturing sector also show considerable gain. Here, Maharashtra experiences the highest impact in terms of employment generation. Again, the additional impact accruing due to enhancement of domestic capacity is quite significant. Two non-target states that need to be highlighted in case of Electrical Engineering and Instrument and Other Manufacturing sectors, respectively, are Jharkhand and Odisha, both of which exhibited significant impact in terms of employment.

3. **Impact on the Steel Sector**

Table 5.9 categorises the states in three bins depending on the range of the average growth of Industry Output of the 'Basic Metals' sector.

As can be observed from Table 5.9, the states that experience the maximum impact, Maharashtra and Karnataka, are among the leading states in terms of both crude steel production and steel use. As of 2015, Maharashtra ranked first in terms of steel use while Karnataka ranked 4th. Their corresponding position in terms of crude steel production was 6th and 3rd, respectively (WSA, 2018). Gujarat, Tamil Nadu and Haryana are other major manufacturing hubs that are among the leading steel users, with relatively lower share in the crude steel production. Uttar Pradesh, being ahead of Haryana in both steel production and use, does not experience a commensurate impact. Other states belonging to the last category

Table 5.9 Average % difference from baseline for industry output of basic metals sector (2020–2030)

Sr. no	*Average growth range of industry output*	*States*
1	Greater than 10%	Maharashtra, Karnataka
2	5–10%	Gujarat, Tamil Nadu, Haryana
3	Less than 5%	Uttar Pradesh, Jharkhand, Chhattisgarh, Odisha

Source Results from the model

contain the major crude steel-producing states with the highest iron ore deposits, viz. Jharkhand, Chhattisgarh and Odisha. All these states are relatively under developed and do not have well developed domestic market for their steel production (WSA, 2018).

These results suggest that the states which benefit the most are the ones which possess the strongest forward linkages with the basic metal sector as well as the two sectors representing the CG sector, thereby giving an edge to the states having leading manufacturing hubs of the country. The major steel-producing states that lack access to immediate markets will not stand to gain considerably unless adequate investment is made in the requisite infrastructure in areas such as railways, roadways, power generation and distribution (Ministry of Steel, 2017).

The major sectors influenced by this policy are all energy intensive sectors, which implies that any increase in production of these sectors is inevitably tied with higher emissions. In order to analyse the extent of the environmental cost imposed by achieving this policy, we look at the average percentage difference from baseline for Electricity Use and CO_2 emissions over the duration of the policy across major states. The results for the same are presented in Table 5.10.

Table 5.10 Average % difference from baseline for electricity use and CO_2 emissions (2020–2030)

Sr. no	*Electricity use*	*Scenario 2.1*	*Scenario 2.2*	*CO_2 emissions*	*Scenario 2.1*	*Scenario 2.2*
	All India	12.44	8.67	All India	2.89	1.68
1	Andhra Pradesh	45.06	24.07	Andhra Pradesh	13.09	7.75
2	Maharashtra	29.66	20.71	Maharashtra	9.23	6.73
3	Haryana	23.81	15.82	Haryana	6.58	4.41
4	Karnataka	9.53	6.57	Karnataka	6.27	4.21
5	Gujarat	6.37	4.74	Uttarakhand	4.47	2.61

Source Results from the model

Results indicate that the states which are responsible for the maximum electricity use are the major CO_2 emitters as well. Andhra Pradesh (including Telangana) is responsible for the highest electricity use and CO_2 emissions. Other states that appear in the list of top five states in terms of electricity use and CO_2 emissions are all leading states that are of strategic importance to the CG sector. Hence, it is crucial for these states to revise their energy policies and incentivise adoption of renewable energy among their major manufacturers of the sector. Otherwise, the environmental cost may soon surpass the economic gain ushered in by the policy.

5.3.3 Results for the Indian Electrical Equipment Industry Mission Plan 2012–2022

The macro-economic impact of this policy will be measured in terms of Gross Disposable Income (GDI). The direct impact will be evaluated through trade and industry employment. Finally, in line with the policy's intention to support the expansion of the power sector, the impact of the policy on the same will be evaluated.

5.3.3.1 Scenario 3

Here we present the impact that an additional production worth USD 75 billion of the Electrical Engineering and Instrument Industry by 2022 will yield on the Electrical equipment sector and the overall economy of different states.

1. **Macroeconomic Impact**

The results for the macroeconomic impact in terms of GDI are presented in Fig. 5.10 in terms of the average percentage difference from baseline value of the respective variable over the entire duration of the scenario, i.e. 2020–2022.

GDI takes into account income generated through direct as well as indirect channels, i.e. in addition to the income generated from the Electrical Engineering and Instrument industry, it also accounts for the income generated through the sectors propelled by an increased output in the electrical equipment sector. Karnataka experiences the maximum gain in terms of GDI followed by Maharashtra. The other three states that are above national average include Madhya Pradesh, Andhra Pradesh and Haryana. All the states that appear among the top performers are the bigger states of the country with comparatively higher installed power capacity.

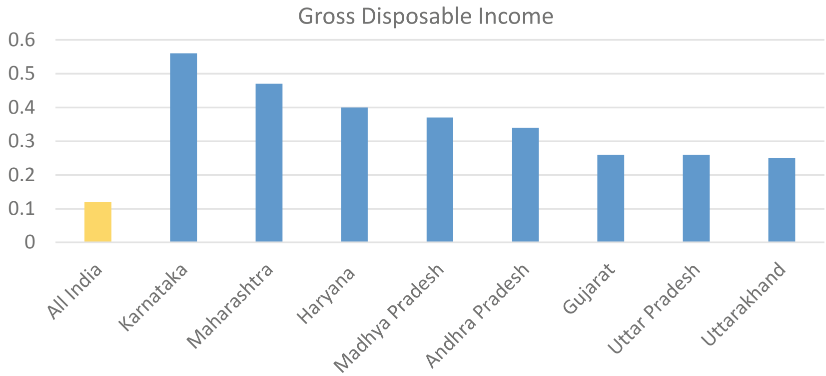

Fig. 5.10 Average % difference from baseline for GDI (2020–2022) (*Source* Results from the model)

2. **Direct Impact**

a. **Trade**

Table 5.11 depicts the direct impact of higher output on trade potential of the top five states.

At the national level, the gain in exports is considerable. Moreover, there is a marginal dip in the imports which can prove beneficial in terms of improving the trade balance of the country. The coastal states of Maharashtra and Gujarat which contribute the most to the country's exports stand to benefit the most in terms of export of Electrical Equipment. However, the polarisation in terms of export potential must be noted. Only four states stand to gain considerably in terms of exports. Madhya

Table 5.11 Average % difference from baseline for trade (2020–2022)

Sr. no		*Exports (%)*	*Imports (%)*
	All India	4.89	−0.10
1	Maharashtra	39.58	−4.97
2	Gujarat	37.11	1.93
3	Haryana	15.01	−3.07
4	Andhra Pradesh	12.29	3.02
5	Madhya Pradesh	2.24	0.54

Pradesh, one of the larger states in terms of area, population as well as installed power capacity, does not perform well in terms of exports. The two states that are able to bring their imports below the baseline level are Maharashtra and Haryana.

The results highlight the export potential of the Indian electrical equipment segment. Currently, there is only around 60% domestic capacity utilisation of the existing facilities while a large portion of the country's electrical equipment requirement is met through imports (Department of Heavy Industry, 2016). This is indicative of the untapped potential that the domestic industry possesses. Therefore, along with becoming globally competitive, equal attention has to be paid to make the industry capable of catering to the requirements of the domestic markets.

b. **Industry Employment**

Figure 5.11 depicts the direct impact of higher output on industry employment of the top eight states.

The Electrical Equipment Mission Plan 2012–2022 had projected that the sector would provide direct employment to 1.5 million people and

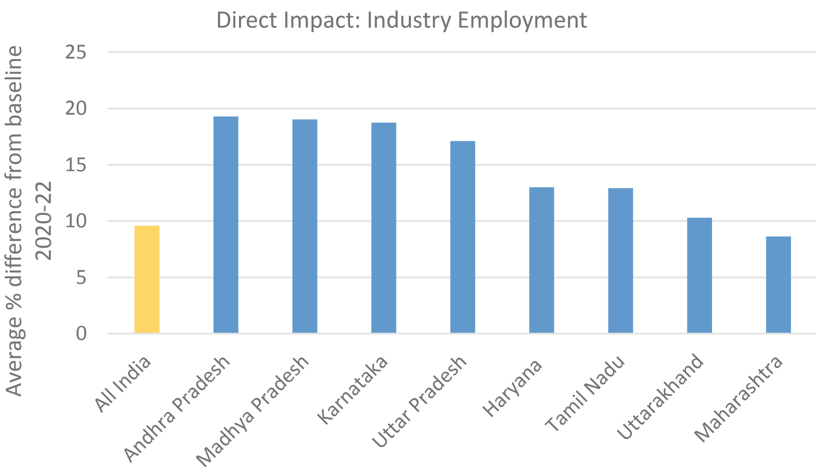

Fig. 5.11 Average % difference from baseline for industry employment (2020–2022) (*Source* Results from the model)

indirect employment to 2 million by 2022. Our results indicate which of the states will be at the forefront of driving this employment generation. Andhra Pradesh, Madhya Pradesh and Karnataka lead the way in terms of generating additional employment opportunities in the Electrical Engineering and Instrument sector. The considerable impact felt across all the major states highlights the inherent potential of the sector to be employment conducive. Similar to the employment results for Scenario 2.1.1, Jharkhand exhibited tangible impact in terms of employment.

3. **Impact on the Power Sector**

As the Electrical Equipment Mission Plan 2012–2022 was formulated to support the government's vision to double India's power generation capacity from 200 GW in 2012 to 400 GW in 2022, it is indeed worthwhile to look at the impact that this policy yields on the prospects of the power sector. For this purpose, we look at the electricity supply and electricity use across different states. The same is presented in Fig. 5.12.

As Fig. 5.12 suggests, the power supply-demand gap varies across states. For Uttar Pradesh, Haryana, Maharashtra and Karnataka, electricity

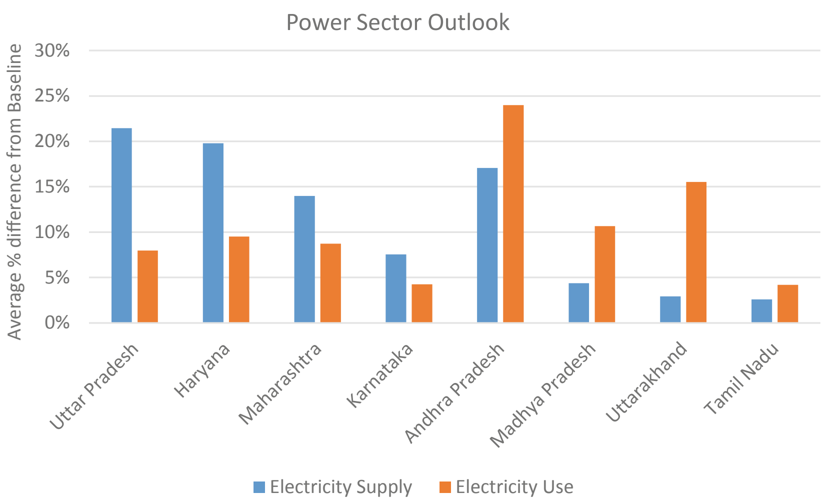

Fig. 5.12 Power sector outlook (average % difference from baseline value [2020–2022]) (*Source* Results from the model)

supply registers a higher growth from the respective baseline value as compared to electricity use. Andhra Pradesh, Madhya Pradesh, Uttarakhand and Tamil Nadu, on the other hand, experience faster growth in electricity use than electricity supply. The performance of Uttar Pradesh, Haryana, Karnataka, Uttarakhand and Tamil Nadu is in line with their current power supply-demand gap, whereby the first three states experienced power surplus during 2019–2020, while the latter two had power deficit over the same time period (CEA, 2019). The results suggest that without any intervention at the regional level, these two states with power deficit will not be able to meet their demand even until 2022.

The performance of Maharashtra, Andhra Pradesh and Madhya Pradesh defies their existing supply–demand gap position. While Maharashtra, which currently faces a slight power deficit, experiences a faster growth in its electricity supply compared to its electricity use, Andhra Pradesh and Madhya Pradesh, having surplus power at present, see their electricity use grow at a much faster rate than their electricity supply. The states facing deficit have the option of sourcing it from those who have surplus power, however, for this inter-state transfer of power supply to occur efficiently, transmission and distribution segment has to evolve simultaneously. Currently, 90% of T&D equipment manufacturers in India are in the small and medium enterprises (SME) sector, who are generally unable to upgrade technology and improve their products (Ministry of Heavy Industries & Public Enterprises, 2013). Therefore, policy intervention to ensure adequate assistance in capacity building and R&D of the segment is necessary.

As this policy was primarily formulated to enable the power sector in enhancing its capacity, gauging its environmental cost becomes utmost critical. For this purpose, we look at the average increase in the CO_2 emissions over the duration of the policy. Figure 5.13 highlights the top five states that experience the maximum increase in their CO_2 emissions. Andhra Pradesh again emerges as a major CO_2 emitter, followed by Uttarakhand. The case of Uttarakhand as a major CO_2 emitter is even more concerning as it is much smaller in terms of both size and capacity as compared to the other states in the list. Hence, it is crucial for the state to revisit its energy mix.

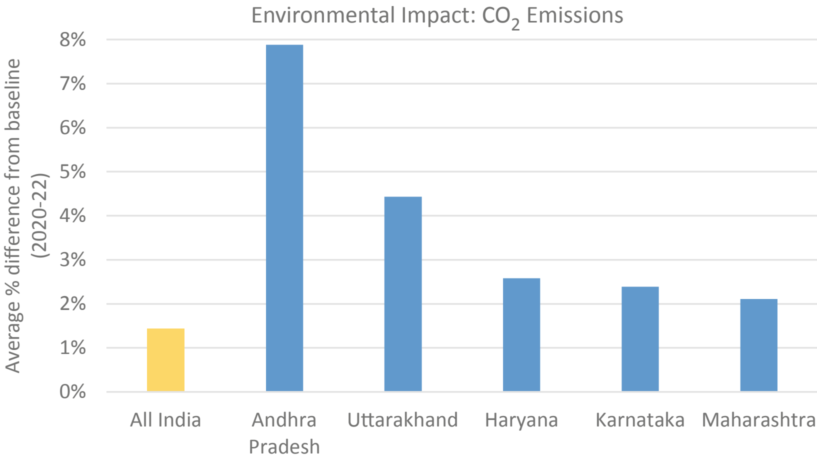

Fig. 5.13 Average % difference from baseline for CO_2 emissions (2020–2022) (*Source* Results from the model)

5.4 Measuring the Reach of These National Policies to Different States

In this section, we attempt to demonstrate the combined impact of the three national policies considered in Sect. 5.2. Here, we will try to put more stress on ordinal measurement of policy implication and will try to reach a conclusive decision regarding choice of policies. To this end, we have represented our results differently to capture the reach of the three government policies discussed here having direct and indirect impact on Indian States. We will try to find out whether the benefits of these three policies have been able to reach individual States with reasonable amount of uniformity. For this analysis, we will concentrate on two primary dimensions of any ordinal measurement:

(i) If the policy component has been able to extend its access to a particular State and
(ii) Whether the state has been able to capture benefit or not.

Table 5.16 in the appendix shows that the total number of possible impacts that a state can possibly experience when all the three policies are considered together is 36. This figure is the total number of possible impact in terms of all E3-India variables for which the results have been presented in Sect. 5.3, under each policy. Using this we have calculated the percentage of ways a State has been impacted by the set of three policies. This percentage gives a fair idea about the intensity with which the three national policies have been able to impact different States.

Table 5.12 presents the results for the combined impact of all the three policies. The different columns of this table can be explained in the following manner: HITS can be defined as the variable impact count, i.e. the number of variables in terms of which the respective state experienced a tangible impact. The next column represents the HITS as a proportion of total possible impacts (36). The next three columns indicate the scenarios for each policy under which the respective state experienced a tangible impact. Finally, the Policy Impact Count sums the number of scenarios in the previous three columns to indicate the number of scenarios under which a State experiences a significant impact.

From Table 5.12, it is clear that it is only in Haryana, Maharashtra and Karnataka, that the concerned CG policies have been able to leave a deep influence. Maharashtra and Karnataka being essentially industrial states, this result is however very much expected. However, the results pertaining to Haryana are to some extent surprising as well as encouraging.

Table 5.12 Combined impact of all three national policies

Sr. no	*States*	*HITS*	*% of total possible impacts*	*Policy no. 1*	*Policy no. 2*	*Policy no. 3*	*Policy impact count*
1	Haryana	30	83.3	1.1, 1.2, 1.3	2.1, 2.2	3	6
2	Maharashtra	29	80.6	1.1, 1.3	2.1, 2.2	3	5
3	Karnataka	27	75.0	1.1, 1.2, 1.3	2.1, 2.2	3	6
4	Andhra Pradesh	20	55.6	1.1, 1.3	2.1, 2.2	3	5
5	Gujarat	20	55.6	1.1, 1.2, 1.3	2.1, 2.2	3	6
6	Uttarakhand	10	27.8	1.2, 1.3	2.1, 2.2	3	5
7	Tamil Nadu	10	27.8	1.1, 1.2	2.1, 2.2	–	4

Source Author's calculations

The extent of policy penetration mainly depends on two factors. Firstly, the readiness of the State to adopt new policy initiative. Participation of private players to supplement government's initiative plays a major role in this. Secondly, supportive State policies to facilitate the new policy initiated at national level. This explains quite well why Haryana has taken such a high position according to our analysis. The State has a high investment rate due to capital accumulation by affluent farmers. Proactive industrial policies adopted by Government of Haryana along with supportive private investment have taken the State to the next orbit of industrialisation process. The State has become an attractive destination for investment and manufacturing of CG.

Almost same reasons also follow for Maharashtra and Karnataka in terms of their excellence in CG industry. However, both the States, unlike Haryana, have a prolonged history of industrial development. The industrial ambience has become so conducive in these two States, so that they always take maximum leverage of any CG policy implemented by the Government in the country. And exactly the same happened in case of the three policies under our consideration.

Some other States which performed well in terms of accessing and accruing benefits from the three government policies are: Andhra Pradesh, Gujarat and Uttarakhand. All of these States have been able to capture at least 40% of possible impact intended. Thus, we can easily demonstrate the differential impact of the Central Government policies in India, owing to the highly diverse socio-economic structures of Indian States.

5.5 Implications of the COVID-19 Pandemic on the Capital Goods Sector

The current pandemic has caused major disruptions in the supply chains of almost all sectors, however, because of its differential impact across countries, some opportunities have emerged as well. In this section, we look at the plausible impact of the pandemic on the CG sector specifically, highlighting both negative as well as positive implications of the same.

Negative Impacts:

- **Stress on working capital**:

The most serious consequence of the COVID-19 pandemic on the CG sector of India has unfolded in terms of a severe crunch in working capital of indigenous companies. Availability of capital has always been a stumbling block for such companies to take off for growth. This perennial scarcity of funds became even more evident since the advent of COVID-19 followed by economy wide lockdown. The onslaught of the pandemic completely took away government's focus from infrastructure and Capital Expenditure (Capex) to immediate crisis management. Complete shut-down of on-going infrastructure projects for a considerably long time period, high fixed costs associated with manufacturing units in the CG sector and recurrent payment delays by existing customers facing liquidity crunch, etc., have collectively put immense pressure on already ailing Indian companies plagued by capital crisis. According to Edelweiss Securities Ltd, in the past it was observed that the down cycles in Gross Domestic Product (FY02, FY08 and FY14) were usually preceded by a healthy economy, but the current crisis set in by COVID-19 was quite unique in the sense that it appeared at a time when the Capex was at a cyclical low (Kamat, 2020). The one-two punch of recessionary forces completely de-railed manufacturing activities of CG firms in India and stretched the working capital requirements beyond previous estimates. The same is shown in Fig. 5.14 for the major CG manufacturers.

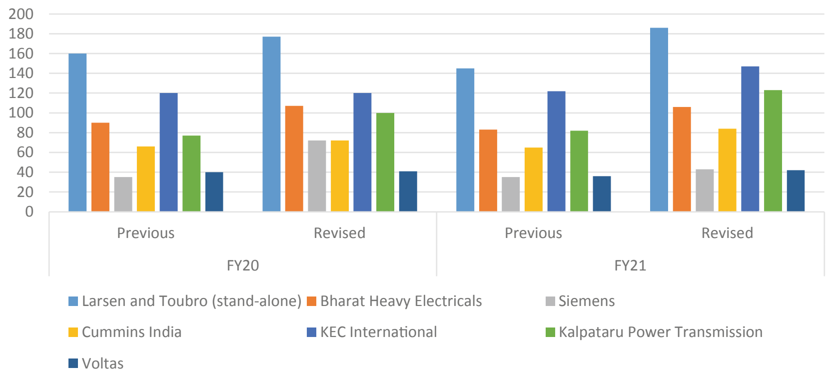

Fig. 5.14 Estimates of net working capital (in no. of days) (*Source* Kamat [2020])

- **Vulnerability due to weak end-market demand**:
  As a result of COVID-19, the end markets of CG in India have weakened substantially. Sectors having weak end markets become more vulnerable given the dramatic decline in demand from the end markets. While higher exposure to weaker end markets will be more vulnerable, the strength of end market is also considered as a decisive credit factor. The major end markets of the CG sector are: Oil & Gas, Aviation, Construction, Material Handling Equipment and to some extent Metals/Mining (Pillay, 2020).

A brief update on these key end markets is as follows (Fukuchi et al., 2020):

(i) **Oil & Gas**: As a result of oversupply and the standoff between Saudi Arabia and Russia, oil prices have plunged. As a result, Capex related to the oil & gas sector will decrease substantially. Reduced activities in the upstream segment will lead to substantial fall in the spending on oil & gas equipment.

(ii) **Aviation**: Most of the airline companies were compelled to ground their fleets due to imposition of travel restrictions to contain spread of virus. As a result, Capex on design and manufacture of components for engine and airframe systems has been substantially curtailed.

(iii) **Metals/Mining**: The demand for industrial metals have plunged dramatically since late 2019 by slowing economic growth in the USA, China and EU, particularly in the important construction and automotive sectors. This coupled with recessionary impacts of Coronavirus pandemic and a sharp fall in oil prices will result in a drop in demand for key metals. The mining/metal companies will substantially cut down their Capex on mining equipment and machineries, which will in turn affect CG industry adversely.

As a direct consequence of adverse impact of COVID-19 on CG sector, the entire manufacturing sector of India has been negatively affected (Sabharwal, 2020). According to the latest government data available with Ministry of Statistics and Programme Implementation, Government of India, industrial production shrank by 10.4% in July 2020 (Press Trust of India, 2020), mainly due to lower output of manufacturing, mining and power generation sectors. According to the Index of Industrial Production (IIP) data, factory output had registered a growth of 4.9% in July 2019. Meanwhile, the fall in IIP for June 2020 has been revised to (-) 15.77% from the provisional estimates of 16.6% contraction released last month. The IIP for April-July period has contracted by 29.2%, according to the data. It had registered a growth of 3.5% during the same period last fiscal. Power generation shrank by 2.5% as against a growth of 5.2% a year ago.

- **Supply chain disruption restricting capacity and output**:
  As an aftermath of COVID-19, the CG sector is likely to experience severe supply chain disruptions. Complete closure of production facilities, lack of market demand and labour shortage will lead to disrupted supply lines. The supply chain cannot be restored, unless and until the demand for CG in the end markets is fully recovered. Industries as well as countries operating with a diversified supply chain will be able to better mitigate supply chain disruptions compared to those reliant on a limited number of facilities.
- **Job cut and furloughing**:
  To survive is a situation characterised by depressing revenue figures for a considerably long period, most of the companies in CG sector will resort to cost reduction measures like job cut and furloughing. For a country like India, such measures have many adverse socio-economic implications.

Positive Impacts:

- **New opportunities for growth**:
  Amid all adverse impacts, the COVID-19 pandemic also offers the Indian CG industry new opportunities for growth (EEPC India, 2020). Government of India resorted to the policy of "Atmanirbhar Bharat" mainly to reduce burgeoning import of crucial commodities, including CG. In the past, India has been relying heavily on import of CG from China, which has been a global supply hub of CG for quite a long period of time. But the situation has dramatically changed since the advent of COVID-19. There has been a growing allegation that China's deliberate attempt to conceal crucial information about fatality of COVID-19 virus ultimately resulted in

the global spread and caused huge death toll globally. As a result, a growing dissent against China was formed among the international community. Countries like USA, UK, Japan and Australia took a strong stance against Chinese aggression over South China Sea dispute. Apart from COVID-19 outbreak, India had to take on Chinese aggression over border issues at Ladakh. Countries like Australia, USA, Mexico and many others are also trying to reduce their dependence on China. They are now looking for alternate sourcing hub for import of crucial commodities, including CG. This has created a huge opportunity for Indian entrepreneurs in CG sector. The entire domestic market as well as a sizable portion of international market of CG products is now open for them. If India caters to the domestic market and strengthens exports, it can become one of the largest manufacturing hubs and can replace China as the biggest exporter.

- **Potential in Global Value Chains (GVCs)**:

  Another major opportunity that has unfolded in the wake of the pandemic is in the form of the missing links that have been created as a result of supply chain disruptions across different product lines in many well integrated GVCs and RVCs. Particularly in South Asia, which is known for well-connected value chains in manufacturing sector, emergence of missing links in post-COVID scenario highly affected the production processes. In addition to that, global manufacturers have gone into a mode of diversifying supply chains to mitigate the adverse impact of supply disruptions. In this context, India stands to gain immensely provided it is able to reconstruct its supply chain, to emerge as a stable sourcing hub post-COVID outbreak.

5.6 Conclusion

The National policies concerning the entire CG sector suggest that all these have a significant macroeconomic impact on Maharashtra, Haryana, Karnataka and Andhra Pradesh. The potential of smaller states like Chhattisgarh, Odisha and Jharkhand is highlighted as well, indicating that a similar policy replicated at the state level can benefit the CG sector of these states immensely. Gujarat, Maharashtra and Haryana emerge as the major states benefiting in terms of exports. Overall, Haryana emerges as a major employment generator, with Jharkhand posing as another promising candidate. However, these policies do not prove to be employment conducive for the states of Maharashtra and Gujarat, despite having a significant impact on their GDP and output. This suggests that it is imperative for these states to direct policy attention and additional resources towards employment generation in the CG sector to avert signs of jobless growth as indicated by the model. Meanwhile, for other bigger states like Madhya Pradesh, Tamil Nadu and Uttar Pradesh, additional stimulus is required at the regional level to bring their performance at par with their share in the national CG sector. Andhra Pradesh accounts for really high electricity use and hence high emissions. Efficient allocation of resources to ensure reduced emissions is utmost important for the state.

Therefore, two broad policy options that emerge from this policy analysis exercise are as follows: while bigger states need to focus on enhancing their exports and exploring renewable options to keep emissions in check, smaller states and emerging players like Haryana and Uttarakhand need to pay attention to boosting their output through appropriate incentives at regional levels and simultaneously invest in renewable energy options in order to emerge as promising candidates in the CG sector with a strong foundation to keep their growth sustainable.

Before the advent of COVID-19, initiatives, such as affordable housing, expansion of railway networks, development of domestic shipbuilding industry, opening up of defence sector for private participation and the anticipated growth in the automobile sector, were expected to create significant demand for CG in the country. However, the pandemic completely shifted the focus from all ongoing projects to immediate crisis management. Meanwhile, the emerging geo-political perspective of South Asia in the post-COVID-19 scenario and months long faceoff with China in Ladakh created a strong compulsion to increase domestic output of CG products to such a level, so that the dual objective of import substitution (from China) and export promotion (to other countries searching for alternative supply base) can be simultaneously achieved. But this will never be possible if the severe shortage of working capital in CG sector is not substantially alleviated through concerted efforts by Government and private sector. Considering current fiscal position of the country, capital investment of such an enormous amount does not seem realistic in distant future. The idea of "Atmanirbhar Bharat" or "Self-reliant India" as envisaged by Prime Minister Modi has put almost entire onus of replacing import by domestic output on private sector only. But Indian CG companies are mostly low-end SMEs with very limited capacity of capital expansion. Hence banning import of CG from China can go against the interest of the country in the long run and can lead to disruptions in other manufacturing lines as well. Hence, Government of India should consider possibility of import substitution, only after alleviating the serious capital crunch that COVID-19 has inflicted on the sector.

The transformation of Indian CG sector from a low-end to a high-end one will require investment in human talent as well as in research and development. Countries like the USA, Germany and China were able to produce quality CG because they have invested heavily in R&D, innovation and intellectual property ecosystem. Thus, a combination of initiatives including investment in R&D, facilitating policy atmosphere, global quality standards, a public procurement policy, skill development and supporting marketing mechanisms can create an environment for fostering growth in the CG sector. Overall, it will require sustained efforts by all stakeholders to accelerate demand creation and to create an efficient production mechanism.

5.7 Policy Recommendations

The economic reforms in India during the 1990s opened up the CG market through the FDI route, and in the year 2000, FDI up to 100% was allowed under automatic route in companies engaged in the manufacture of CG. According to a latest survey of multinational corporations (MNCs) conducted by the Confederation of Indian Industries (CII) and EY, India has emerged as the leading choice for FDI. The survey found that India is set to become one of top three destinations for FDI inflow by 2025 (Dutta, 2020). As per the Global Investment Trade Monitor 2019 report by the UNCTAD, India's FDI inflow grew by almost 16% in 2019 bringing it up to $49 billion (PTI United Nations, 2020). Despite this commendable achievement, there is a serious issue with FDI flow in the country. It has been observed that sectoral distribution of FDI flow in India has been highly unequal. For instance, while automobile receives a sizeable proportion of FDI, other product categories do not have significant share. This is especially true for the machinery sector. This is demonstrated in Table 5.18 which gives the sector-wise cumulative FDI between April 2000 and March 2020. Therefore, there is a need to direct more investment towards CG sectors which can lead to development in technology and high-value-added production capacity.

The National Capital Goods Policy, 2016, by virtue of its in-depth analysis of sub-sector specific issues has been successful at identifying a comprehensive set of issues ailing the CG sector followed up with a plethora of practical recommendations. However, the implementation of the same has been sluggish. Some of the major recommendations that the policy had made that still remain to be implemented or have witnessed a very slow progress but are highly critical for the sector include the following: rationalising inverted duty structure and local taxes, improving technological competency of India CG manufacturers with special focus on MSMEs and increasing investment in R&D. The results of the India National Innovation Survey, 2014, with special focus on MSMEs, has highlighted the role of machinery and equipment (imported) towards enhancing the innovation capability of firms across sectors. This shows the importance of acquiring new machines as a part of innovation activities vis-à-vis sourcing technology or knowledge through patent or know-how, which is at best marginal. Regional analysis of the innovation potentiality suggests that Karnataka, Andhra Pradesh, Tamil Nadu and Maharashtra are the most innovative states (NSTMIS,DST GOI, 2014). As indicated by our results, these are also the states that respond relatively well to the CG sector policies discussed in the chapter. Hence directing regional policy and resources to leverage this potential becomes imperative.

Given that the policy has also provided estimates of sub-sector specific unutilised capacity in the CG sector, an in-depth analysis of the factors hindering optimal capacity utilisation is critical. Another major area for further analysis is identifying products for import substitution. For instance, it has been observed that in case of harvesting and threshing machines, while export is substantial there is very high negative trade balance as well. Similarly, under textile machinery, spinning, weaving, combing and carding machineries have registered significant export growth but the trade balance has been found to be almost negative (EEPC India, 2020). Both these instances qualify for strong cases for import substitution. Therefore, a sub-sector level evaluation is necessary to identify CG products where import substitution is feasible and desirable. Moreover, both these analyses need to be supplemented by a regional analysis approach. As the results presented in this chapter provide evidence that the impact of national-level policies is felt differentially across states, with only a few states able to reap the intended benefits substantially, the different requirements of different states need to be brought within the ambit of policy making. Without any realistic knowledge about the same, the government's intention to focus on cluster-based development will only lead to further concentration of manufacturing capability within a few states while the other states possessing potential but lacking the infrastructure will be left further behind.

Appendix

Calculation of total number of possible impacts to gauge the combined impact of all the three policies in terms of their reach to different states as given in Sect. 5.4. Table 5.16 shows how the total number of possible impacts were calculated while Table 5.17 summarises the results of Sect. 5.3 for each variable to enable the computation of HITS shown in Table 5.12 in Sect. 5.4.

The results of E3-India model can be summarised for each variable as shown in Table 5.17. The numbers in the parentheses denote the number of routes a State is impacted in regard to a particular variable (Image 5.2).

Table 5.13 State-wise share for output and investment scenarios

	Electrical Engineering and Instrument		*Other manufacturing*	
Sr. no	*State*	*Share in value of gross output (%)*	*State*	*Share in value of gross output (%)*
1	Maharashtra	24.56	Maharashtra	26.36
2	Gujarat	11.47	Tamil Nadu	19.51
3	Karnataka	11.33	Gujarat	13.80
4	Andhra Pradesh[a]	8.80	Karnataka	8.42
5	Tamil Nadu	7.86	Haryana	6.95
6	Madhya Pradesh	6.45	Punjab	4.71
7	Haryana	4.67	Uttar Pradesh	4.07
8	Uttar Pradesh	4.03	Uttarakhand	3.62
9	Uttarakhand	3.37	Rajasthan	2.77
	All India	100.00	All India	100.00

[a]Andhra Pradesh includes Telangana

Source State wise share has been calculated from Annual Survey of Industries, 2017–2018, retrieved from EPRFW Database (2018)

Table 5.14 State-wise share for employment scenarios

	Electrical Engineering and Instrument		*Other manufacturing*	
Sr. no.	*State*	*Share of employment (%)*	*State*	*Share of employment (%)*
1	Maharashtra	19.29	Maharashtra	21.51
2	Andhra Pradesh[a]	13.71	Tamil Nadu	18.04
3	Karnataka	11.25	Gujarat	17.61
4	Gujarat	10.34	Karnataka	7.96
5	Tamil Nadu	9.99	Haryana	6.10
6	Madhya Pradesh	6.02	Punjab	5.57
7	Haryana	5.79	Uttar Pradesh	5.48
8	Uttar Pradesh	4.98	Andhra Pradesh[a]	3.98
9	Rajasthan	2.54	Uttarakhand	3.18
10	Uttarakhand	2.51	Rajasthan	2.48
11	West Bengal	2.45	West Bengal	2.21
	All India	100.00	All India	100.00

[a] Andhra Pradesh includes Telangana
Source State wise share has been calculated from Annual Survey of Industries, 2017–2018, retrieved from EPRFWDatabase (2018)

Table 5.15 State-wise share for export scenarios

	Electrical Engineering and Instrument		*Other manufacturing*	
Sr. no	*State*	*Share of exports (%)*	*State*	*Share of exports (%)*
1	Maharashtra	25.03	Maharashtra	33.81
2	Uttarakhand	9.52	Gujarat	15.20
3	Karnataka	8.41	Tamil Nadu	14.75
4	Rajasthan	6.88	Karnataka	12.70
5	Tamil Nadu	6.78	Punjab	3.50
6	Uttar Pradesh	6.65	Haryana	3.46
7	Gujarat	5.70	Uttar Pradesh	2.96
8	Madhya Pradesh	4.85	Rajasthan	2.58
9	Haryana	4.49	West Bengal	2.51
10	Andhra Pradesh[a]	3.22	Uttarakhand	0.86
	All India	100.00	All India	100.00

[a] Andhra Pradesh includes Telangana
Source E3-India model

Table 5.16 Variables and parameters measured for HITS calculation

Policy	*Scenario*	*Parameters*	*Variables*
1	1.1	Y	Regional income
		X_EEI	Export of Electrical Engineering and Instrument
		M_EEI	Import of Electrical Engineering and Instrument
		X_OM	Export of Other Manufacturing Sector
		M_OM	Import of Other Manufacturing Sector
		N_OM	Employment in Other Manufacturing Industry
		Y_COAL	Sectoral Output: Coal
		Y_O&G	Sectoral Output: Oil and Gas
		Y_BM	Sectoral Output: Basic Metals
		Y_MG	Sectoral Output: Metal Goods
		Y_ELEC	Sectoral Output: Electricity Supply
		C_ELEC	Electricity Use
		E_CO_2	CO_2 emissions
Total number of possible impacts: 14			
1	1.2	Y	Regional Income
Total number of possible impacts: 1			
1	1.3	Q	GDP
		Y_EEI	Industrial Output of Electrical Engineering and Instrument
		Y_OM	Industrial Output of Other Manufacturing

Policy	*Scenario*	*Parameters*	*Variables*
Total number of possible impacts: 3			
2	2.1	Q	GDP
		N_EEI	Employment in Electrical Engineering and Instrument Industry
		N_OM	Employment in Other Manufacturing Industry
		Y_BM	Sectoral Output: Basic Metals
		C_ELEC	Electricity Use
		E_CO_2	CO_2 emissions
Total number of possible impacts: 6			
2	2.2	Q	GDP
		N_EEI	Employment in Electrical Engineering and Instrument Industry
		N_OM	Employment in Other Manufacturing Industry
		C_ELEC	Electricity Use
		E_CO_2	CO_2 emissions
Total number of possible impacts: 5			
3	3	Y	Regional Income
		X_EEI	Export of Electrical Engineering and Instrument
		M_EEI	Import of Electrical Engineering and Instrument
		N_EEI	Employment in Electrical Engineering and Instrument Industry
		C_ELEC	Electricity Use
		Y_ELEC	Electricity Supply
		CO_2	CO_2 emissions
Total number of possible impacts: 7			
Total number of possible impacts: 36			

Table 5.17 Combined impact of three national level capital goods policies

Impact	*Variables*	*Beneficiary states*
Macroeconomic impacts	Q	MAH, GUJ, HAR, KAR, UK
	Y	HAR (2), KAR (2), GUJ (2), MAH (1), TN (2), UK (1)
	Y_STEEL	MAH, HAR, KAR, GUJ, TN
	Y_EEI	MAH, AP, HAR, UK, KAR
	Y_OM	MAH, UK, HAR, UP, KAR
Direct impact on trade	X_EEI	GUJ(2), MAH(2), HAR(2), AP(2), MP(2)
	X_OM	MAH, HAR, GUJ, UK, KAR
	M_EEI	AP(2), GUJ(2), KAR, UP(2), TN, MP(1)
	M_OM	MAH, HAR, UK, GUJ, KAR
Direct impact on industry employment	N_EEI	MAH(3), KAR(3), UP(3), TN(3), HAR(3), UK(2), AP(2)
	N_OM	HAR(2), MAH(2), UK(2), PUN, AP, KAR, GUJ, UP, TN
Indirect impact on other sectors	Y_COAL	AP, MAH, TN
	Y_O&G	AP, RAJ, TN
	Y_BM	MAH, HAR, MP
	Y_MG	MP, AP, KAR
	Y_ELEC	HAR(2), UP(2), MAH(2), KAR, AP, MP, UK, TN
Impact on energy consumption and CO_2 emission	C_ELEC	AP(3), UK(2), HAR(2), MAH(2), MP(2), KAR, GUJ,CHH
	E_CO_2	UK(3), HAR(3), AP(3), MAH(3), KAR(3), GUJ, MP

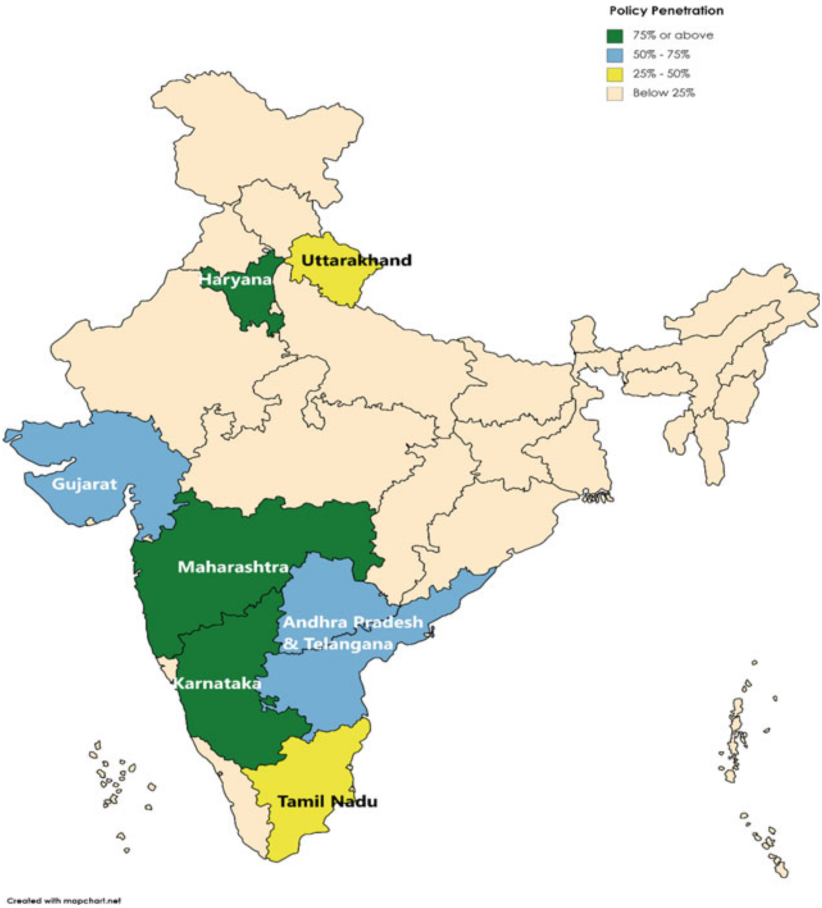

Image 5.2 Combined impact of all three national policies (*Note* Analysis in E3-India includes Andhra Pradesh and Telangana combined hence presented together. *Source* Created by Authors)

Table 5.18 Sector-wise cumulative FDI, April 2000–March 2020 (USD million)

Sr. no	*Sector*	*FDI*	*Share (%)*
1	Automobile	24,210.68	5.1
2	Metallurgical industry	13,401.78	2.9
3	Electrical equipment	8604.02	1.8
4	Industrial machinery	5619.5	1.2
5	Misc. mechanical and engineering industries	3636.79	0.8
6	Medical and surgical appliances	2129.5	0.5
7	Railway related products	1107.6	0.2
8	Machine tools	980.78	0.2
9	Agri. machinery	574.48	0.1
10	Earth moving machinery	466.8	0.1
11	Commercial office and household equipment	388.88	0.1
12	Scientific instruments	286.84	0.1
13	Boiler and steam generating plants	263.37	0.1
14	Industrial instruments	88.36	0
15	Mathematical surveying and drawing instruments	7.98	0
16	Subtotal	61,767.36	13.1
	Total	470,119	

Source DIPP (2020)

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CHAPTER 6

Impact of Electronics System and Design Manufacturing and IT Policy in Selected Regions

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6.1 Introduction

The changing global market dynamics have demanded high level of sophistication and technological innovation in the Electronic System

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and Design Manufacturing (ESDM) industry and the Information Technology (IT) and IT-enabled Services (ITeS) across the world. The evolution of ESDM and IT contributed significantly to the transformation of hardware equipment and software segments and making India the 5th largest economy in the world in the twenty-first century.

In 2017–2018, the Indian electronics hardware production was estimated to be USD 64 billion (INR 38,75,250 million) with 3% share in global production and contribution of 2.3% in the national GDP. The industry turnover has grown almost three times its size in 2009–2010 to USD 23 billion, at a CAGR of 14%. However, with increasing consumer demand, India's electronic imports have also increased to USD 55 billion in 2018–2019, compared to the exports of USD 8.9 billion in the same year, making it a large net importer of electronic products. With demand for electronics hardware expected to reach USD 400 billion by 2025, India aims to increase its manufacturing capacity and decrease its dependency on imports. This ambition is also aligned with the Make in India initiative of the central government.

'Digital India' is another major initiative announced by the government in which it wants to increase the penetration of IT services such as high-speed internet, e-commerce, cashless transactions, educational services for all Indian households. With more than 75% of IT sector revenue being generated by exports, the Digital India initiative intends to use the huge capacity of IT services for promoting inclusive economic growth. Of the half a billion internet users in the country today, 45% of the total internet subscribers in the last 4 years have come from states with per capita GDP lower than the national level. The Digital Adoption index of World Bank group states that India is the second fastest emerging digital economy in terms of digital adoption in the last 3 years (MEITY, 2019a). With the rapid level of digital penetration in the country, the government intends to achieve a 'digital economy' of USD 1 trillion by 2025.

The software product segment generates revenue of USD 7.1 billion with a global share of only 1.7%. The total imports stood at USD 10 billion compared to exports of USD 2.3 billion, making India a net importer of software products. The IT industry is expected to reach USD 350 billion by 2025 and contributing 10% to national GDP. In this endeavour, the software product segment is expected to play an important role by providing increase in employment opportunities for skilled IT workers. However, the unexpected arrival of COVID-19 pandemic resulting in consequent lockdowns as well as layoffs by many companies has stagnated the industry's plans in the present and in the near future as well. Due to the unpreparedness as well as the uncertainty the world is facing, the expected growth of the software industry in the next 5–6 years has been reduced by as much as six percentage points.

The ESDM and IT sectors are aiming to achieve multiple targets for which the state-level contribution will play a significant role. However, different states belong to different development strata and have varying economic and demographic characteristics. With the help of E3-India model, this heterogeneity across states resulting from various sectoral policies announced by the ESDM and IT industries can be captured. The comprehensive description of E3-India model is provided in Chapter 2.

Section 6.2 and 6.3 provide a comprehensive overview of the ESDM and IT sector in India. In Sect. 6.4, the national and state-level scenarios are explained followed by results and discussion in Sect. 6.5 and conclusion in Sect. 6.6.

6.2 The Electronics System and Design Manufacturing (ESDM) Industry in India: An Overview

The electronics industry holds a key position in the Indian manufacturing space today due to its contribution and being a leading employer in the economy. However, its growth was not a steady one, with lot of stagnation experienced during the early stages. Along with other manufacturing industries in India the ESDM sector was not able to capitalize on the 1991 economic liberalization reforms due to the existing weak physical infrastructure and lack of technological know-how amongst the entrepreneurs in the industry (Kapur, 2002). It is only in the last decade that the industry witnessed rapid transformation and growth as a result of various governmental initiatives such as the National Policy on Electronics 2012 (MEITY, 2012a), Make in India initiative (2016), as well as the additional impetus for domestic manufacturing from localized indigenous inputs proposed by the *Atmanirbhar Yojana* 2020. Since the beginning of the last decade the production capacity increased at double digit growth rates shown in Fig. 6.1.

In last ten years, the electronics production grew at a CAGR of 17% as a result of which today, it is a USD 84.4 billion industry constituting

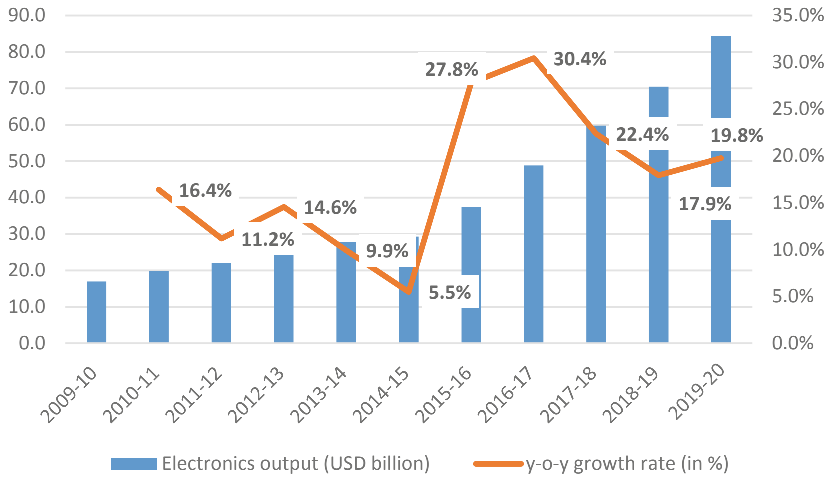

Fig. 6.1 Electronics industry output (2009–2020) (USD billion) (*Source* Ministry of Electronics and Information Technology, Government of India Annual Reports)

a share of approximately 3% in the global electronic hardware production of USD 2 trillion and contributing 2.3% to the national GDP (MEITY 2019d). The segment-wise shares of the electronics industry are shown in Fig. 6.2.

The rapid growth in various segments has contributed significantly to the Indian economy in terms of manufacturing capacity, investment and employment generation. Figure 6.2 shows that consumer electronics (including mobile phones) segment constitutes more than 50% of the consumer durables industry. India is host to the third largest television manufacturing industry and second largest mobile handset manufacturing in the world (Mondal, 2019). Automotive electronics which is a part of industrial electronics segment is also an upcoming and fast-growing segment constituting approximately 2% global production share (ASSOCHAM & NEC, 2018). As a result of fast-growing demand, the electronics industry is expected to reach USD 400 billion in 2025 from USD 70.5 billion in 2019, growing at a CAGR of 34% in the given period (IBEF, 2019a).

With the expected increase in demand, there is additional pressure on domestic manufacturing to boost the scale of production. Currently India

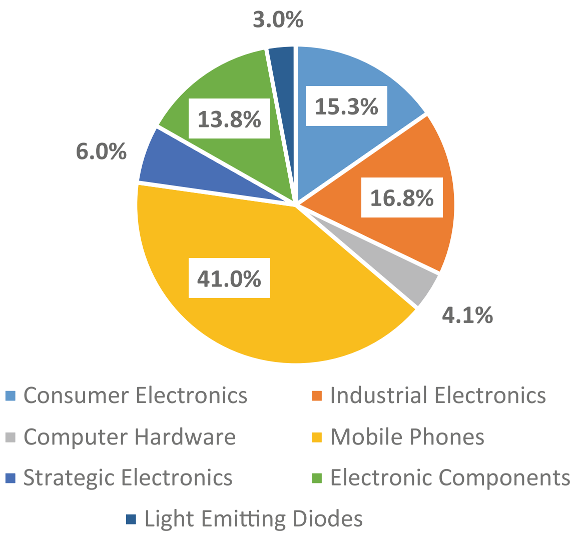

Fig. 6.2 Segment-wise share of electronics hardware manufacturing (in percentage) (2019–2020) (*Source* Ministry of Electronics and Information Technology, Government of India Annual Reports)

is a large net importer of electronics products with approximately USD 57 billion worth imports in 2018–2019 vis-à-vis only USD 8.8 billion worth exports during the same financial year (MEITY, 2020). India's exports have largely remained stagnant whereas imports have gradually increased every year.

The contribution of electronics industry to the national GDP for other developing countries in Asia is much higher, such as 15.5% in Taiwan, 15.1% in South Korea and 12.7% in China, compared to only 2.3% in India (NITI Aayog, 2016). Furthermore, the total foreign direct investment received by the industry from April 2000 to June 2015 was USD 1.68 billion which was only 0.58% of the total FDI inflows in India. Under the Make in India initiative, NITI Aayog, the government economic think tank analysed the reasons for lack of higher valuation of electronics industry in India compared to that of China which is a global manufacturing hub of almost all manufacturing sectors. The report finds that China adopted an export-oriented growth strategy by providing a highly simplified tax structure along with a world-class ecosystem through provisions such as the Special Economic Zones (SEZ), thus attracting various global multi-national companies in the country. India's policies are converging to that of China's with the only difference that the gestation period for setting up manufacturing system in India is very long. It is only recently that India has been proposing measures for capacity building, encouraging investment by allowing 100% FDI by automatic route in the electronics sector (SESEI, 2017), easing of tax structure, and through the rollout of Goods and Service Tax (GST) in 2016 such that the potential of electronics manufacturing can be realized.

The government has undertaken various initiatives supporting Research and Development in order to gain competitive edge in the global electronics market. R&D divisions within the government departments range from electronics system development to nano-technology initiative divisions (MEITY, 2018). The National Mission on Power Electronics Technology (NaMPET, 2020) Phase III focusses on development of power electronics segment in India, thus encouraging and funding premier engineering and technology universities focussing on laboratory level research and building various novel electronic prototypes adopting greener technologies and energy efficiency (MEITY, 2019b). However, there is no large-scale monetary allocation for R&D activities in the ESDM sector, thus leaving a vacuum for advanced technology adoption at the national as well as state level.

According to the Indian National Innovation survey, conducted by Department of Science and Technology, Government of India, the innovation activities in electronics sector are undertaken predominantly by the larger firms (NSTMIS, 2014). The electronics sector is also deemed to be a capital-intensive sector, where only larger firms have the monetary capacity to innovate and find novel solutions to improving their products.

The government has also proposed the formation of Electronics Manufacturing Clusters (EMCs) in 2012, providing financial assistance for creation of world-class manufacturing and attracting large-scale investments by covering 50 and 75% of project cost for Greenfield EMC and Brownfield EMC (subject to a ceiling of USD 7.6 million for each) (MEITY, 2012b). In 2020, the policy was revised with financial assistance provision of 75% with a ceiling of USD 10.7 million irrespective of the type of the project as well as for Common Facility Centres (CFCs) (PIB, 2020). In 2019–2020, twenty Greenfield EMCs across the country were approved with a project cost of USD 600 million.

With the demand for electronic products expected to grow to USD 400 billion, without increasing local/indigenous production capacity on a large scale will lead to higher dependence on imports and worsening India trade balance. Thus, the electronics manufacturing hubs across the country will play a lead role in increasing its production capacity in order to meet the rising domestic demand.

6.3 The Rise of IT and Software Industry in India

The Indian IT industry has experienced tremendous growth since the economic reforms of 1991. Prior to the reforms, the sector's evolution towards adoption of new software technologies in order to make it compatible to the continuous upgradation of hardware equipment not just related to IT, but other sectors such as telecommunications, electronics (automotive and industrial) and other manufacturing segments was limited due to various licensing and business outsourcing restrictions. However, post-1991 reforms, the IT industry was one of the lead beneficiaries amongst other industries primarily due to access to various financing options from domestic and international sources, the most effective being raising funds through equity as previously debt financing was highly restricted due to lack of collateral (Kapur, 2002). The IT sector has benefitted the most growing at a rapid pace since the economic reforms which was primarily due to one comparative advantage the sector had compared to other sectors, which was low-cost highly skilled labour (Kapur, 2002). This led many global MNCs enter the Indian IT market such that by 1999, of the 95 Global MNCs in the IT sector, 70 entered India after 1990 (Kumar, 2001). By 2000, India was producing 65,000 engineers and 95,000 diploma holders eligible to work in the IT sector which became one of the largest organized sector employers providing 340,000 jobs with a turnover of USD 8.26 million, catapulting India's growth to higher levels in the twenty-first century.

Today, the service and telecommunications sector along with the IT industry's application in software product segment is one of the largest recipients of Foreign Direct Investment. Between 2000–2020, the service sector has been the highest recipient of FDI with USD 83.1 billion followed by computer hardware and software sector with USD 45.9 billion and telecommunication sector with USD 37.2 billion (DIPP, 2020). Today, the Indian IT sector is a USD 168 billion industry constituting 3.5% of the global IT industry share and is the largest organized sector employer providing 14 million direct and indirect jobs (MEITY, 2019c), contributing 8% to the national GDP. In addition, more than 200 Indian IT companies have established their presence in 80 countries across the world. It is also highly export oriented with 75% (USD 126 billion) of the total revenue generated by exports which also constitutes approximately 30% of total exports from India.

We can see from Fig. 6.3 that revenue from exports have been growing at a faster rate than revenue from domestic services at a CAGR of 11 and 6% respectively in the given period. It is primarily through the outsourcing of IT and BPM (Business Process Management) segments to India by global MNCs from the west. As we can see, the IT support services or ITeS constitute the largest share of export revenue in the IT industry. An upcoming sector in which IT services plays a significant role is the e-commerce industry which has seen an exponential growth over the last decade, with market size of USD 14 billion in 2014 to USD 64 billion by 2020, growing at a CAGR of 24.25% (Statista, 2020).

The growth in e-commerce industry in India is primarily due to the adoption of online platforms to execute various services by the Micro, Small and Medium Scale Enterprises (MSMEs) which play a significant role in the Indian economy, constituting 45% of the total manufacturing and 40% of total exports from India (UNIDO, 2017). By adopting online services, SMEs can experience growth in their businesses primarily due to reduction in advertisement and distribution costs by 60–80% as a result of

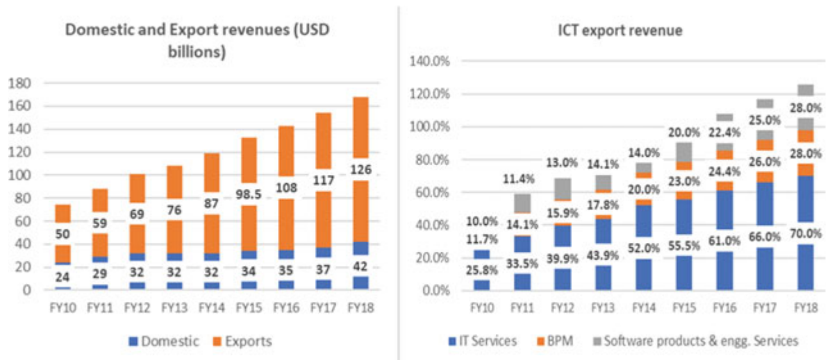

Fig. 6.3 Share of domestic and export revenues in the IT industry (USD billion) (FY10–FY19) (*Source* [IBEF, 2019b])

which there is a shorter time lag to market and reduced inventory costs, compared to MSMEs which continued to serve offline (KPMG, 2015). Another determinant for the rapid growth of the e-commerce platform is the increasing level of digital footprint in the country. Today, India has the second largest internet subscribers and instant messaging service users and largest social media users in the world with internet penetration of 54.29% in FY19 which is second highest behind China (IBEF, 2020). According to the digital adoption index published by World Bank group, India recorded 2nd fastest growth rate amongst 17 emerging digital economies in the world (McKinsey Global Institute, 2019). Thus, it is inevitable that with rising digital adoption, there needs to be robust IT infrastructure presence in order to cater to the needs of the internet users.

The software product segment which is characterized by innovations, intellectual property rights in order to increase productivity as well as create entrepreneurial opportunities generated a revenue of only USD 7.1 billion of which USD 2.3 billion was exported but USD 10 billion worth of software products were imported as well, which makes it a net importer (MEITY, 2019c). The overall software products segment has a very miniscule share in the global software industry of USD 413 billion. This is primarily due to lack of regulatory support and bureaucratic delays which hinder and discourage the cultivation of innovation ideas as a result of which it becomes difficult to compete with the more developed western countries which have relatively more conducive ecosystem. The major export destinations for Indian IT companies is shown in Fig. 6.4.

We can see that USA and Canada are the prime export destinations, followed by Europe in which UK constitutes 11% of total Indian IT exports. The Indian IT companies established in the USA play a significant role in the US economy as they provide an average compensation of USD 96,300 which is higher than the average wages provided by local US companies which is USD 94,800 with an additional direct and indirect job creation in the USA of 5.2 million (Phadnis, 2020).

There are various regions in India which have grown at a faster rate relative to others as a result of which majority of IT companies are concentrated in few metro cities in India. Bengaluru the capital of Karnataka has long been the IT hub of India which constitutes 39 and 55% of total global IT companies in software and Telecom & Networking sectors, respectively (Oza, 2020). Other regions such as Delhi, Hyderabad (Andhra Pradesh), Chennai (Tamil Nadu) and Pune (Maharashtra)

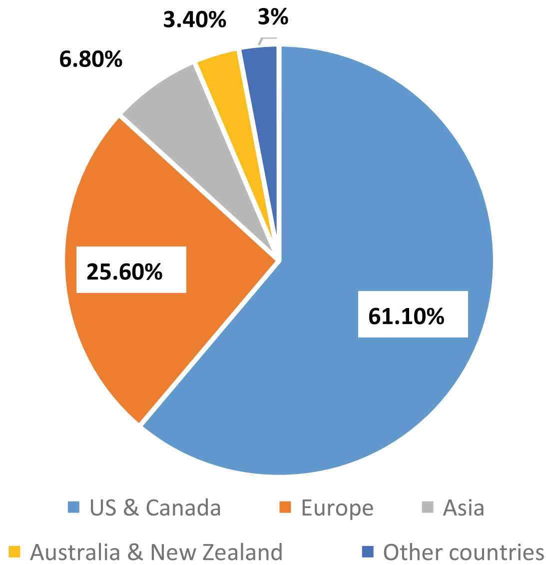

Fig. 6.4 Export destinations for Indian IT companies (2018–2019) (*Source* [RBI, 2019])

have also prospered in recent years with increasing concentration of IT companies.

The government of India has set a target of achieving USD 1 trillion dollar Digital economy by 2025 aiming to assist various sectors ranging from financial services, e-governance, health care, energy-related services as well as support various government policies such as the National Electronics Policy, Doubling Farmer's income for Agriculture sector, Make in India initiative for manufacturing sector, skill development, education as well as enhancing IT infrastructure and software capabilities (PIB, 2019). This has provided a huge impetus for Business-to-Business (B2B) and Business-to-Customer (B2C) e-commerce services such that the expected number of online consumers is expected to grow from 180 million in 2018 to 350 million with an annual turnover of USD 200 billion by 2026 (IBEF, 2020). In this endeavour, all the states will have to progress in development of IT infrastructure for equitable distribution of digital penetration across the country in order to promote inclusive growth. However, the COVID-19 pandemic has brought about significant changes in the behaviour patterns of consumers opting for IT services. This has also influenced the current operational policies in the

IT industry with different regions coping with resulting changes in the economy as per their existing economic potential.

This chapter assimilates the current status of the Electronics and IT sector in India as discussed in Sect. 6.2 and 6.3 and evaluates the impact of various national and sub-national policies using the E3-India model. In the next section, the national and state-level scenarios with respect to the existing Electronics and IT sector policies are addressed.

6.4 Scenario Development

6.4.1 Electronics Sector Policies

I. **Scenario 1: National Electronics Policy (NEP) (MIETY, 2019d)**—*Electronics industry Output to reach USD 400 billion by 2025.*

The Government of India has itself highlighted the factors affecting Indian electronics sector's competitiveness in the global market. These are poor infrastructure, unstructured domestic supply chain and logistics, high financial cost, lack of components manufacturing base and limited focus on R&D and skills development within the domestic market. As a result, the key market players, namely the ASEAN countries along with Korea and Japan who have gained a comparative advantage in these factors, have continued to be net-exporters of electronics products especially to the western countries, whereas India remains a net importer despite accounting for 3% of global electronics manufacturing (MIETY, 2019d). In order to reverse this trend, the government announced the National Electronics Policy (2019) to increase the electronics manufacturing capacity to the tune of USD 400 billion by 2025 from the current level of USD 64 billion. The top ten states based on electronics hardware manufacturing constituting more than 87.3% of the total manufacturing across the country will play a pivotal role in achieving USD 400 billion by 2025. The increase in production levels is allocated according to the state-wise production shares as shown in Table 6.1.

Of the USD 329 billion output increase required between 2019–2025 from USD 71 billion in 2019, 87.3% or USD 288 billion is expected from the top ten states as shown in Table 6.1.

Table 6.1 State-wise increase in electronics hardware production between 2019–2025—NEP

Sr. no	*States*	*% share in national electronics hardware manufacturing*	*Increase in electronics hardware production in order between 2019–2025 (USD billion)*
1	Uttar Pradesh	31.4	90.26
2	Tamil Nadu	15.1	43.39
3	Andhra Pradesh[a]	14.8	42.70
4	Maharashtra	10.2	29.34
5	Karnataka	7.2	20.77
6	Haryana	2.3	6.64
7	Gujarat	2.1	6.09
8	Rajasthan	1.7	5.01
9	Delhi	1.2	3.59
10	Kerala	1.2	3.42

Note [a]Andhra Pradesh includes Telangana as well
Source EPWRF Database (2020) and Authors' calculations

II. **Scenario 2: Electronics Manufacturing Policy Uttar Pradesh, (2020)**—*Uttar Pradesh state electronics manufacturing policy (2020) targets investment of USD 6.1 billion to the electronics sector between 2020–2024.*

With the largest consumer base in India with more than 200 million people and the Gross State Domestic product of USD 200 billion, Uttar Pradesh aims to capitalize on its potential of becoming a leading manufacturing state. The state is the largest producer of electronics goods in the country, especially mobile handset manufacturing and for the semiconductor industry as well with several MNCs having their presence in the state along with R&D centres. With the policy, the state government aims to further its ambition of providing world-class ecosystem for electronics manufacturing with prime focus on promoting the large number of MSMEs in the state.

6.4.2 IT Sector Policies

I. **Scenario 3: Digital India Initiative (MIETY, 2019a)**—*Increase in digital penetration and adoption across different sectors and regions of* *the country such that in order to achieve a Digital Economy of USD 1 trillion by 2025.*

The 'Digital India Initiative' was launched in 2015 with the objective of transforming India into a knowledge-based economy by ensuring digital services are accessible and affordable to all. The initiative is based on three key pillars: (a) digital infrastructure as a utility to every citizen, (b) governance and services on demand and (c) digital empowerment of citizens. Thus, the Digital India Initiative will influence not only the functioning of public and private sectors in the economy but also the day-to-day life of each citizen in the country. With a population of approximately 1.2 billion, ensuring digital penetration across the country is a monumental task, especially considering the infrastructural and literacy gap in the rural regions where a vast proportion of the country resides. However, since its inception, the government has made tremendous progress by becoming the second largest digital consumer in the world and achieving second fastest growth of digital adoption amongst the emerging digital economies (MEITY, 2019a). As a result, the government aspires to achieve a digital economy of USD 1 trillion by 2025 accounting for 25% of national GDP by adopting digital services across agriculture, manufacturing and service sectors as well as in the day-to-day lives of consumers.

The top ten states together constitute 72.9% of the total services GDP in the country. In order to reach USD 1 trillion by 2025 from USD 200 billion, an increase of USD 800 billion is required in the IT-BPM service sector. Of the USD 800 billion, 72.9% output (USD 583 billion) will be achieved by the top ten states as per their output shares in the service sector mentioned in Table 6.2.

- *Scenario 3.1: COVID-19 impact on e-commerce industry*

The COVID-19 induced lockdown has led to changes in shopping patterns of consumers as well as the working style of various professionals in the service industry. Furthermore, the usage of internet platform for accessing various Business-to-Business (B2B) as well as Business-to-Consumers (B2C) has increased tremendously during this period. As a result, the contribution of e-commerce industry to the Digital India initiative is expected to result in reaching USD 1 trillion economy by

Table 6.2 State-wise increase in digital economy output (2019–2025)

Sr. no	*States*	*% share in Services GDP (in percentage)*	*Share in national level digital economy output increase (USD billion)*
1	Maharashtra	15.6	124.89
2	Karnataka	9.0	72.24
3	Andhra Pradesh[a]	9.0	71.93
4	Tamil Nadu	8.5	67.84
5	Uttar Pradesh	7.8	62.09
6	Delhi	6.6	52.83
7	West Bengal	5.9	47.01
8	Gujarat	5.5	43.70
9	Kerala	4.7	37.74
10	Rajasthan	4.3	34.19

Note [a]Andhra Pradesh includes Telangana as well
Source Handbook of Statistics on Indian States, Reserve Bank of India 2018–2019 and Authors' calculations

2023 itself instead of 2025 with a CAGR of 19.6% between 2020–2023 (Laskar, 2020). Thus, with higher demand expected in the e-commerce industry, we look at its impact across various regions. The Digital India Initiative constitutes digital penetration across a number of sectors such as financial services, e-commerce, transport and logistics, public utilities as well as promotion of digital adoption in agriculture and manufacturing sectors as well. It should be noted that this COVID-19 scenario looks at narrow impacts of COVID by assuming higher demand for e-commerce industry on Digital India Initiative only.[1]

II. **Scenario 4: National Software Policy (NSP) (MEITY, 2019c)**—*Increase in the output of IT industry to achieve the target of USD 350 billion and generate additional employment of 3.5 million by 2025.*

With the aim of becoming a leading software exporter and sustaining the large share of the global IT-BPM industry, the National Software Policy (NSP) aims to increase the market share of the IT industry from

[1] It does not capture wider impacts of COVID such as national lockdown and spike in unemployment which lead to reduction in income, consumer spending and GDP.

USD 168 billion in 2019 to USD 350 billion in 2025 as well as generate employment of 3.5 million in the software industry segment.

The states which will play a significant role in implementation of this policy are the same as shown in Table 6.2, as states with the largest share in Services-GDP are already endowed with robust IT infrastructure compared to other states.

In order to achieve USD 350 billion IT industry turnover by 2025, an additional increase of USD 182 billion is required between 2019–2025. The state-wise allocation of the additional output target as per the state-wise service sector shares as shown in Table 6.3.

The top 10 states will achieve USD 132.7 billion and 2.7 million additional jobs of the total USD 182 billion and 3.5 million, respectively, to be achieved by 2025.

- Scenario 4.1 COVID-19 impact on Software industry

The ongoing pandemic has led to a slowdown in the service sector, leading to stagnation in new job creation and lesser demand internationally. This has also led to layoffs in the software industry across the country.

Table 6.3 State-wise increase in software industry output (2019–2025)

Sr. no	*States*	*% share in Services GDP (in percentage)*	*Share in national level IT industry output increase (USD billion)*	*Share in national level software industry employment increase (in '000)*
1	Maharashtra	15.6	28.4	546
2	Karnataka	9.0	16.4	316
3	Andhra Pradesh[a]	9.0	16.4	315
4	Tamil Nadu	8.5	15.4	297
5	Uttar Pradesh	7.8	14.1	272
6	Delhi	6.6	12.0	231
7	West Bengal	5.9	10.7	206
8	Gujarat	5.5	9.9	191
9	Kerala	4.7	8.6	165
10	Rajasthan	4.3	7.8	150

Note [a]Andhra Pradesh includes Telangana as well

Source: Handbook of Statistics on Indian States, Reserve Bank of India 2018–2019 and Authors' calculations

As a result of the prolonged impact of COVID even after the lockdown being eased in a number of phases in various states, the growth rate of the software industry has been dialled down to 7.6% CAGR compared to the pre-COVID scenario of 13% CAGR between 2019–2024 (PTI, 2020). The impact of this slowdown on the National Software policy is also analysed for this scenario.

6.5 Results and Discussion

The E3-India modelling framework provides a comprehensive outlook across various socio-economic and environmental indicators. In E3-India model, the results are generated through the two way linkages from the inter-industry transactions, inter-state trade and the recursive feedback loops between the economy, energy and emissions modules within the model.[2] For the scenarios discussed above in Sect. 6.4, we look at the impacts to 2030 as percentage difference from baseline across the period for Electronics and IT sector scenarios and medium-term impact till 2025 for the two COVID scenarios. The impact on macroeconomic indicators such as employment, consumer expenditure as well as its implications on trade is observed through changes in exports and imports from the respective scenarios. The indirect impact arising from the inter-industry transactions as well as the environmental impact arising from higher CO_2 emissions is also analysed for the respective scenarios.

I. **Electronics sector policy impacts**

In this sub-section, first the impact of National Electronics Policy (NEP) at the regional level followed by State Electronics policy for Uttar Pradesh is discussed.

i. *National Electronics Policy (Scenario 1)*

The highest overall positive impact of the NEP across various macroeconomic variables is seen for Andhra Pradesh and closely followed by Uttar Pradesh (Fig. 6.5). Andhra Pradesh is a relatively high per capita income state and India's fourth largest electronics manufacturer which

[2] The detailed description is provided in Chapter 2.

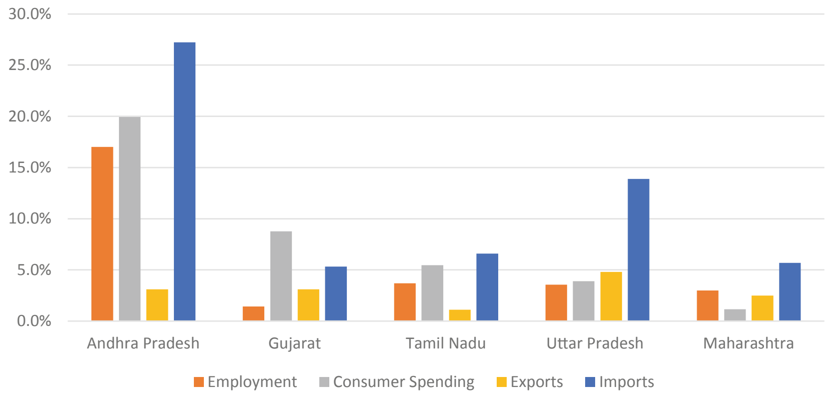

Fig. 6.5 Average % difference from baseline for macro-economic indicators (2020–2030)—NEP (*Source* Results from the model)

has seen an exponential increase in the growth of electronics sector. The Electronics Manufacturing Clusters (EMCs) where the government gives special emphasis for electronics manufacturing by providing various supply-side incentives has seen a rapid increase in Andhra Pradesh with twenty EMCs which is one of the highest in the country (APEDB, 2020). According to the National Innovation Survey, Government of India, (2014), Andhra Pradesh ranks in the top five for innovation intensity and innovation potentiality across 26 states in which the survey was conducted.[3] Andhra Pradesh also ranked third for product and process innovation, thus gaining the competitive edge in the Indian market which is seen in the electronics sector as well. Amongst the states shown in Fig. 6.5, Andhra Pradesh's GDP growth rate has been one of the highest in the past ten years, averaging at 7.4% per annum and this has been reflected in the various components of GDP in our analysis as well (Indiastat Database, 2020). It has also been ranked as number one in terms of Ease of Doing Business by the World Bank which is also an indicator

[3] The National Innovation Survey defines innovation intensity as the ratio between number of innovative firms and total number of firms in the respective states. Innovation potentiality is defined as the weighted innovation intensity, where the weights are share of a state in total innovative firms.

as to why a large number of Global MNCs would want to set up their manufacturing base in the state.

With all these factors contributing towards making Andhra Pradesh a key player in the electronics market, the increase in **employment** level above the baseline is also the highest for the state. It is closely followed by Uttar Pradesh, Tamil Nadu, Maharashtra and Gujarat. Gujarat also has eight EMCs which is expected to generate 30,000 jobs and turnover of USD 16 billion by 2021 (Vibrant Gujarat, 2017). Uttar Pradesh is India's largest manufacturer in the ESDM sector and a prime manufacturing hub for consumer electronics especially mobile handsets. UP has also gained the reputation of being one of the largest hubs for semiconductor industry manufacturing in the country as well (UP investors Summit, 2018). It sees the second largest increase in employment level which is 2.38% leading to higher purchasing power of the consumers. The increase in **consumer spending** is higher for more developed states in terms of per capita income relative to Uttar Pradesh, which are Andhra Pradesh (20%), Gujarat (9%) and Tamil Nadu (5%). Uttar Pradesh largely remains an agrarian state with a high percentage of population in the Below Poverty Line (BPL) category, whereas the other three states mentioned above with higher consumer expenditure are relatively richer and hence, the spending levels are also expected to be higher.

For **exports,** we see that Uttar Pradesh shows the largest increase. Uttar Pradesh is currently the largest exporter of consumer electronics from India and this trend is observed in our results as well (UP investors Summit, 2018). With thirteen Special Economic Zones (SEZs) and EMCs dedicated to electronics manufacturing, Tamil Nadu constitutes 42% share of computers and peripherals equipment and 37% share of testing and control equipment manufacturing in the country (MPRA, 2015). The state also accounts for 21.8% of total electronics exports from the country and our results also show Tamil Nadu amongst the top five exporters of electronic products (Govt. of Tamil Nadu, 2019). Furthermore, with a number of capital-intensive MNCs present in Tamil Nadu along with electronics MNCs, the state is also known for adoption or acquisition of advanced technologies in its manufacturing activities. According to the National Innovation Survey conducted by Government of India (2014), Tamil Nadu ranks first in terms of technology transfer through acquisitions and thus utilizing it for various purposes (NSTMIS, 2014). However, in terms of **imports,** Uttar Pradesh and Andhra Pradesh along with other states such as Maharashtra, Tamil Nadu and Gujarat are also net-importers in the electronics goods supply chain. Nevertheless, all the states show increase in employment generation with different magnitudes implying that states are domestically manufacturing various components in the supply chain at various levels.

Various electronic products are also used as intermediate goods in other industries as well. The resulting indirect impact on various ancillary industries is estimated here. The NEP policy across various regions show that the more capital-intensive industries of Basic Metals, Chemicals, Metal Goods, Electrical Equipment as well as Motor Vehicles are seen to be benefitted the most, compared to light industries (Table 6.4).

Here we again see Uttar Pradesh as the largest beneficiary. The National Capital Region (NCR) is host to numerous industries due to its close connectivity with Gurugram, the capital city of Haryana and Noida in Uttar Pradesh. Thus, the increase in automobile manufacturing also benefits Uttar Pradesh and Delhi through this policy. States such as Karnataka, Gujarat and Tamil Nadu are also known not only for various industrial establishments within their states, but are also leading manufacturers of auto-components which constitute various electronics and

Table 6.4 Average % difference from baseline for indirect impact on sectoral output (2020–2030)

Sr. no	*Sector*	*Regions*	*Sectoral output increase (%)*
1	Motor Vehicles	Gujarat Uttar Pradesh Delhi	Below 5
2	Metal Goods	Uttar Pradesh Delhi Tamil Nadu	9–14
3	Chemicals	Uttar Pradesh Andhra Pradesh Karnataka	10–20
4	Electrical equipment	Uttar Pradesh Tamil Nadu Karnataka	12–25
5	Basic Metals	Uttar Pradesh Tamil Nadu Delhi	Above 25

Source Results from the model

electrical equipment as well as heavy industries such as metal goods, and basic metals in its supply chain. Gujarat is also seen as a leading automobile hub, with expected share of automotive industries in the engineering products of 10% (Vibrant Gujarat, 2017). Tamil Nadu is one of the key states in the casting of iron & steel and casting of non-ferrous metals segments of the basic metals industry whereas Uttar Pradesh is an exclusive exporter in basic metals sector (Biswas et al., 2014). Thus, the growth of electronics production leads to complementary effect on numerous industries as well.

Overall, we see that Andhra Pradesh benefits the most from NEP scenario and as a result of increased manufacturing activity, the state also sees the largest increase in CO_2 emissions of more than 35% (Fig. 6.6). On the other hand, states such as Uttar Pradesh, Karnataka, Tamil Nadu and Maharashtra have also seen increase in not only the electronics output but in various ancillary industries as shown in Table 6.4. Thus, these states also see high increase in CO_2 emissions above baseline level in the long-run. Uttar Pradesh, which is the largest manufacturer of electronics products also has a state policy on electronics manufacturing which is operational along with the NEP. The results of state UP policy are discussed below.

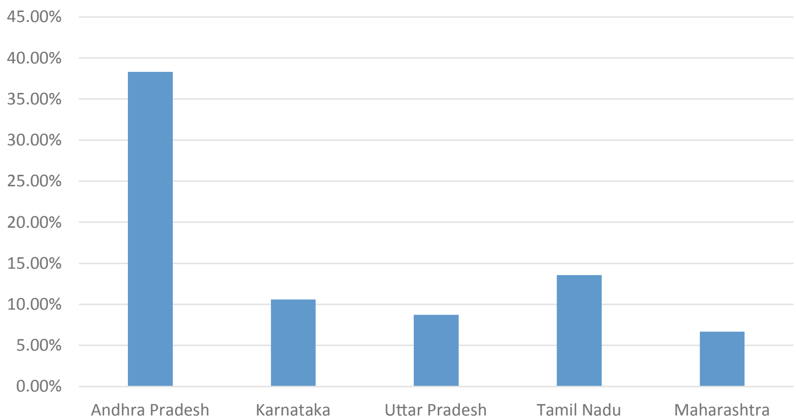

Fig. 6.6 Average % difference from baseline for CO_2 emissions (2020–2030)—NEP (*Source* Results from the model)

ii. *Uttar Pradesh Electronics Policy (Scenario 2)*

The state electronics manufacturing policy for Uttar Pradesh also reiterates the same trends as seen for the national electronics policy, where there is an overall positive impact across all macroeconomic indicators such as output, employment, consumer expenditure as well as trade. In Fig. 6.7, the year-wise macroeconomic impacts are shown.

We can see that the increase in output is also positively correlated with imports and having relatively minimal impact on exports, implying that Uttar Pradesh continues to remain a net importer of electronics components. Due to additional employment generation, there is an increase in household income translating to increase in consumer spending as well which is also a factor for increase in imports resulting from increased level of demand by consumers.

The indirect impact of the state electronic policy should benefit Micro, Small and Medium scale Enterprises (MSMEs) as Uttar Pradesh has one of the largest shares of MSMEs in India which specialize in engineering goods such as electrical equipment as well as capital-intensive goods such as basic metals and metal goods industry.

The state policy of Uttar Pradesh also leads to an increase in manufacturing for Basic Metals, Metal Goods and Electrical Equipment industries.

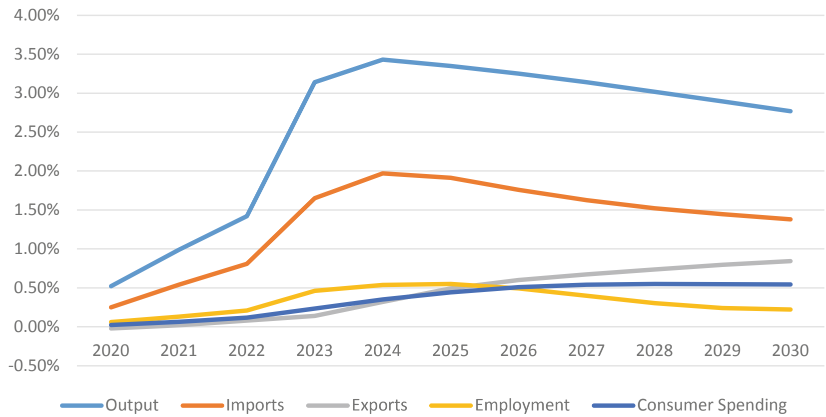

Fig. 6.7 Annual % difference from baseline for macro-economic variables (2020–2030)—Uttar Pradesh Electronics Policy (*Source* Results from the model)

Table 6.5 Average % difference from baseline for indirect impact on sectoral output and sectoral employment (2020–2030)—Uttar Pradesh Electronics Policy

Sr. no	*Sector*	*Sectoral output (%)*	*Sectoral employment (%)*
1	Basic Metals	5.93	1.56
2	Metal Goods	1.22	1.66
3	Elect. engg. and instruments	2.92	3.72
4	Banking & Insurance	1.77	0.13
5	Other Business Services	0.34	0.22

Source Results from the model

The largest increase in employment is also seen for Electrical Equipment sector (3.72%) (Table 6.5). This also reiterates the interlinkages between Electronics and Electrical Equipment sectors as they both form the ESDM segment and are complementary segments. The state policy also leads to increase in output over the baseline for various service sectors through forward linkages as well. As mentioned above it is the capital industries that are largely benefitted as a result of which there will be increase in credit availability to support these industries, hence we see an increase output and employment for Banking and Insurance sector. Other Business Services constitute various technical and professional services, which is again needed for upstream activities such as customer care, logistical support.

The state policy for Uttar Pradesh also shows an average increase in CO_2 emissions of 0.47% between 2020 and 2030 resulting not only from increase in electronics manufacturing but also from other capital-intensive industries as shown in Table 6.5. The peak CO_2 emissions of 1.15% are reached in 2024 and 2025 after which the annual CO_2 emissions start decreasing. This is due to the increase in efficiency of technologies used in manufacturing which not only emit lesser CO_2 emissions but are also less energy intensive. The evolution of greener and efficient technologies in the economy has been incorporated through the Future Technology Transformation (FTT)[4] within the E3-India model.

[4] For further details refer to Chapter 2.

II. **IT sector policy impacts (Scenarios 3 and 4)**

Here the macroeconomic, indirect and environmental impact of the two national-level scenarios developed for the Digital India Initiative and NSP as well as the two COVID-19 scenarios impact on the e-commerce industry and software industry are discussed.

i. *Macroeconomic impact*

For the **Digital India Initiative (Scenario 3) and NSP (Scenario 4),** all states which we have considered show positive results with varying degrees. The intention of Digital India Initiative was to increase digital penetration across all regions and to encourage adoption of internet services for undertaking various economic activities. Thus, the smaller or less developed agrarian states where the digital presence as well as e-literacy is minimal remains the big challenge for the government to overturn the current level of digital penetration.

In Fig. 6.8 we see that there is a large improvement of digital penetration in smaller states such as West Bengal, Uttar Pradesh and Rajasthan compared to the larger, developed states with higher e-literacy rates such as Karnataka, Andhra Pradesh and Delhi. This is because the larger states have already experienced increase in digital activity over the last several years, through continuous improvement of IT infrastructure as well as increase in the density of urban conglomerates within the states, where the population is more conducive to undertake services over online platforms.

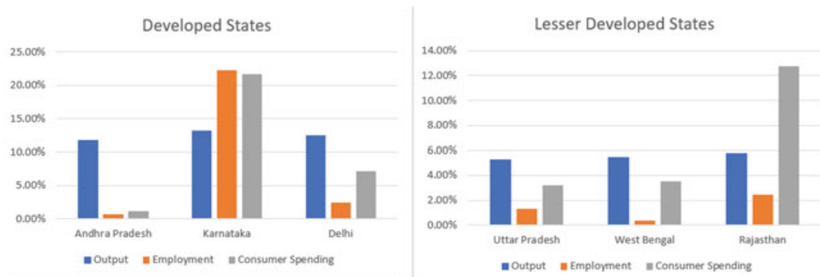

Fig. 6.8 Average % difference from baseline for macro-economic indicators (2020–2030)—Digital India Initiative (*Source* Results from the model)

In the case of smaller states which have relatively less IT establishments also show potential for digital penetration as well as IT infrastructural development.

Delhi has been the largest beneficiary showing the largest increase in regional output in Digital India Initiative (20.4%) and the largest increase in **employment** in both the scenarios with 7.62%. Delhi also experiences the largest increase in **consumer expenditure** with 12.5%. Even though the share of Delhi is fifth highest, it has still benefitted the highest compared to other states. Delhi being the most populous region in the country as well as with a high per capita income, the digital penetration occurs at a rapid pace along with higher consumer spending due to increase in household income levels. On the other hand, smaller states such as Rajasthan have risen exponentially in the IT sector and is challenging the developed states such as Maharashtra, Karnataka and Delhi in attracting young IT professionals for job prospects. The state also hosts one of the largest Special Economic Zones (SEZ) exclusively for IT-ITeS sector of 750 acres accommodating MNCs from across the world (BIP, 2013).

Here again we see from Fig. 6.9 that Delhi benefits the most due to the e-commerce boom, followed by Karnataka and Rajasthan. The changing consumer patterns as well as increasing usage of e-services can also be explained through the increase in the output, employment and household income as well.

Unlike the Digital India Initiative where smaller states benefitted significantly, the National Software Policy will be targeted largely to the

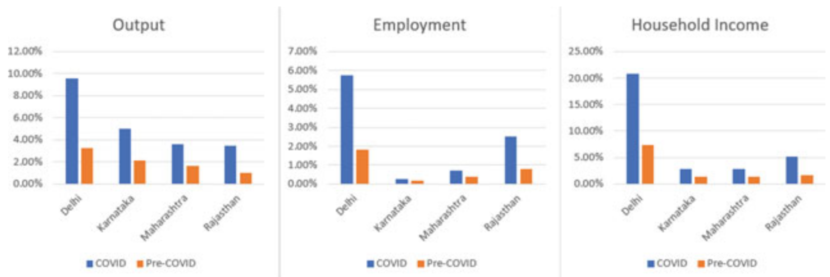

Fig. 6.9 Average % difference from baseline for Output and Employment (2020–2025)—COVID impact on e-commerce industry (*Source* Results from the model)

states with already well-established IT infrastructure. This is because, the software industry which is largely export-oriented segment of the IT sector can cater to the export demand only through the states which are well integrated with the global market. Furthermore, the software industry being a highly technical profession, it will be concentrated in urban conglomerates where all the MNCs will be established and where there will be large availability of talented professionals. Hence, states such as Karnataka, Tamil Nadu and Delhi are the few states which benefitted the most from the National Software Policy.

The National Software Policy itself mentions India is a net importer of software products and here we see that even after the implementation of the software products policy, India still remains a **net importer** with imports increasing the highest for Delhi with 1.6% closely followed by Karnataka with 1.5% and **exports** increasing only marginally with Delhi showing an increase of 0.3% closely followed by Tamil Nadu with 0.13% (Fig. 6.10). Since Delhi sows the largest increase in **employment**, the difference from baseline for **household income** levels is also highest for Delhi followed by Karnataka and Tamil Nadu.

We have seen that in the Digital India Initiative and NSP, we see that Delhi and Karnataka have consistently shown positive results for various macroeconomic indicators for both the scenarios. Delhi and Karnataka have also been home to increasing number of start-ups in recent years as

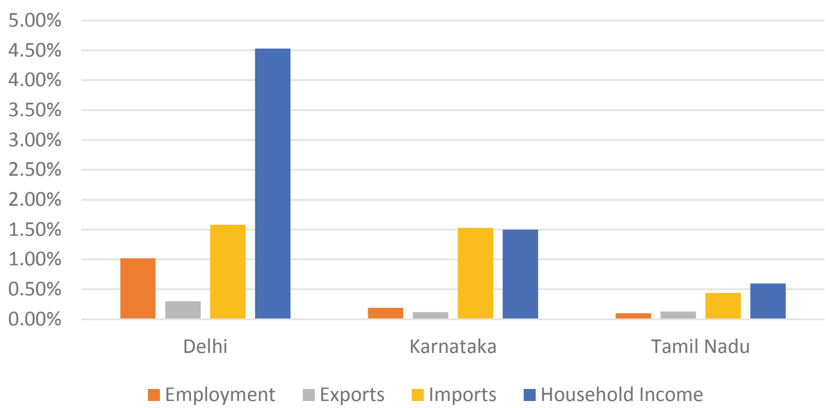

Fig. 6.10 Average % difference from baseline for macro-economic indicators (2020–2030)—NSP (*Source* Results from the model)

a result of which the demand or focus on digital services such as Business-to-Business (B2B) and Business-to-Consumers (B2C) is also bound to increase in the region as a result of which there is increase in imports to satisfy local demand. Furthermore, they are host to a number of IT-ITeS MNCs and key destinations for IT-BPM outsourcing services as well. The small states led by Uttar Pradesh, Rajasthan and West Bengal also show robust increase in various macroeconomic indicators, thus showing that digital penetration can also lead to inclusive growth with the scope of reducing inequality across states.

The results in Fig. 6.11 show lower increase on output of the software industry as a result of COVID-19. As we saw from Digital India Initiative and NSP, Karnataka and Delhi which were the largest beneficiaries are also impacted most from COVID-19 with almost 50% drop in their output as well as employment levels vis-à-vis pre-COVID scenario.

Along with Delhi and Karnataka, other states which are in different economic stratum are affected by the pandemic. The ongoing pandemic is expected to decrease in the magnitude of imports due to reduced consumer demand. In Fig. 6.12, we see the states of Karnataka and Delhi see the largest drop in imports. Other states such as Tamil Nadu, Gujarat and Uttar Pradesh also see decreases in imports due to reduction in consumer expenditure due to the ongoing pandemic.

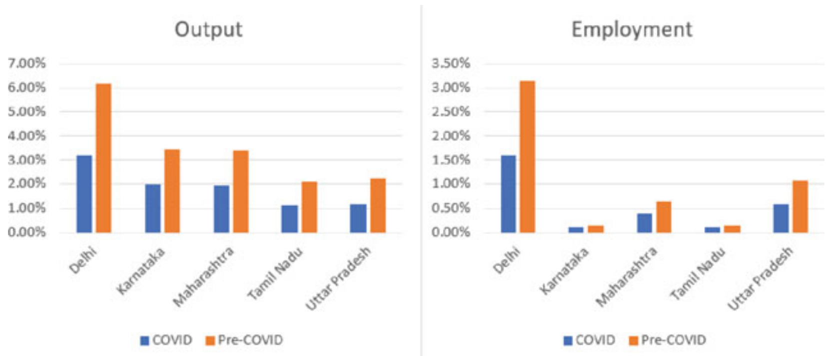

Fig. 6.11 Average % difference from baseline for output and employment (2020–2025)—COVID impact on software industry (*Source* Results from the model)

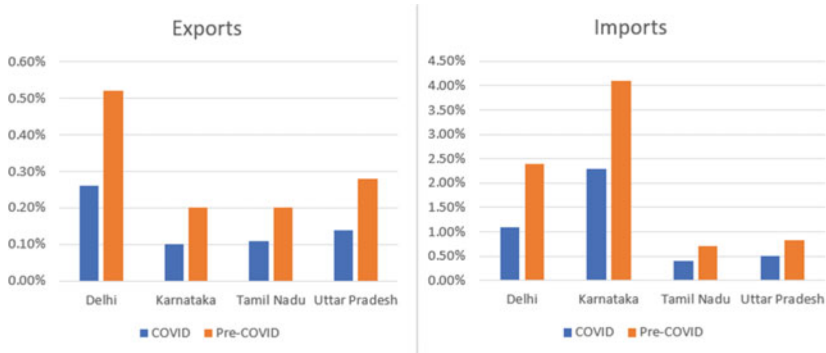

Fig. 6.12 Average % difference from baseline for trade (2020–2025)—COVID impact on software industry (*Source* Results from the model)

ii. *Indirect Impact*

For the IT sector, indirect impact of the Digital India Initiative and (NSP) is observed in various service sectors which are adapting to increased business and economic activities conducted through the internet platform (Tables 6.6 and 6.8). As a result, an increased demand for electricity supply is seen due to higher usage in the commercial, residential as well as industrial sectors. With an increase in e-commerce activity, Trade and Logistics as well as Hotels and Catering services see large increase over the baseline level. With online deliveries becoming a new trend as well as provision of more Business-to-Business and Business-to-Customer services being executed online, the food catering as well as logistical operations has to adapt to changing trends in order to satisfy the consumer needs. Delhi and Gujarat see the largest increase in these two sectors (Table 6.6).

The indirect impact resulting in increase in economic activity also leads to increase in CO_2 emissions. From Table 6.6, we can see that Gujarat and Maharashtra benefit the most in terms of increase in sectoral output.

The COVID-19 impact has also given a positive impetus to the industries involved with e-commerce services. The MSMEs which mostly constitute industries such as Food, Drinks and Tobacco, Rubber and Plastic as well as Textiles and Clothing see a growth in output levels as they are expected to adopt online/internet services to further their

Table 6.6 Average % difference from baseline for indirect impact on sectoral output and sectoral employment (2020–2030)—Digital India Initiative

Sr. no	*Sector*	*Region*	*Sectoral output (%)*	*Sectoral employment (%)*
1	Banking & Insurance	Uttar Pradesh Delhi Gujarat	Below 3	Below 1
2	Trade & Logistics	Delhi Gujarat Uttar Pradesh	Below 5	Below 1
3	Hotels & Catering	Gujarat Delhi Maharashtra	2–13	1–3
4	Air transport	Gujarat Tamil Nadu Delhi	1–6	1–3

Source Results from the model

Table 6.7 Average % difference from baseline for indirect impact on sectoral output and sectoral employment (2020–2025)—COVID impact on e-commerce industry

		Sectoral output		*Sectoral employment*	
Sr. no	*Sector*	*COVID scenario (%)*	*Pre-COVID scenario (%)*	*COVID scenario (%)*	*Pre-COVID scenario (%)*
1	Agriculture	2.88	1.02	0.25	0.10
2	Food Drinks & Tobacco	0.57	0.20	0.09	−0.02
3	Textiles & Clothing	0.11	0.04	−0.41	−0.02
4	Pharmaceuticals	0.06	0.02	−0.75	−0.37
5	Chemicals	0.13	0.06	0.42	−0.14
6	Rubber & Plastics	0.22	0.12	−0.38	−0.13
7	Electricity Supply	1.60	0.71	0.98	0.42
8	Trade and Logistics	1.93	0.75	0.10	0.04
9	Hotels and Catering	3.12	1.13	2.05	0.85
10	Banking and Insurance	1.58	0.57	0.14	0.03

Source Results from the model

Table 6.8 Average % difference from baseline for output and employment (2020–2030)—NSP

Sr. no	*Sector*	*Sectoral output*	*Sectoral output (%)*	*Sectoral employment (%)*
1	Banking & Insurance	Uttar Pradesh Delhi Gujarat	Below 3	Below 0.5
2	Trade & Logistics	Delhi Gujarat Uttar Pradesh	Below 3	Below 0.5
3	Hotels & Catering	Delhi Gujarat Maharashtra	2– 8	Below 3
4	Air transport	Gujarat Maharashtra Tamil Nadu	Below 3	Below 2

Source Results from the model

business activities (Table 6.7). Even capital-intensive industries such as Pharmaceuticals as well as Chemical industries see a small increase in sectoral output. An important point to be noted here is that, with the adoption of internet services, we also see a decrease in employment levels as the middlemen in the supply chains of the respective industries are eliminated since the internet platform provides direct Business-to-Business (B2B) or Business-to-Customer (B2C) services. Forward linkage services such as trade and logistics as well as banking and insurance services also see an increase in their outputs due to an increase in the level of business activities accommodated by various industries.

The increase in software industry output also has a high impact on various service industries due to increasing requirement of privacy security as well as safety measures for online transactions especially in the e-commerce services. As mentioned for UP Electronics Policy, the increasing level of economic activity executed online will also lead to increasing demand for e-services supporting various businesses (Table 6.9).

Here again we see that due to the decrease in CAGR of software products industry, the difference over baseline also diminished to a large extent in the COVID scenario relative to the pre-COVID scenario. Most of the

Table 6.9 Average % difference from baseline for indirect impact on sectoral output and sectoral employment (2020–2025)—COVID-19 impact on Software industry

Sr. no	*Sector*	*Sectoral output*		*Sectoral employment*	
		COVID scenario (%)	*Pre-COVID scenario (%)*	*COVID scenario (%)*	*Pre-COVID scenario (%)*
1	Electricity Supply	0.6	1.2	0.4	0.6
2	Trade and Logistics	0.7	1.4	0.0	0.1
3	Hotels and Catering	1.1	2.2	0.7	1.4
4	Banking and Insurance	0.6	1.1	0.1	0.1

Source Results from the model

service sectors which utilize the software products for various business purposes expect a slowdown in their markets.

For the Digital India Initiative policy, the digital services may not directly impact the service sector, however, as a result of an increase in transport services due to e-commerce business activities being largely affected. Increased motor-vehicle fleet on roads for various logistical purposes in both the backward and forward linkages will lead to higher carbon footprint in the states. Moreover, the scenario results in higher employment and consumer spending leading to higher energy demand and subsequently higher CO_2 emissions from power generations and households. The export-oriented national software policy has minimal impact on CO_2 emissions in the economy.

In Fig. 6.13, we see that CO_2 emissions are the highest in Delhi due to the e-commerce boom impacting the logistics operations. Karnataka, Maharashtra and Tamil Nadu also see a rise in CO_2 emissions primarily because these states are relatively developed in terms of IT infrastructure and with large urban population, high digital or e-literacy rates also contributes to increasing rate of adoption of digital services, which has an indirect impact on various industries serving the customers through the online platform.

We can see from the electronics and IT sector scenarios that the southern states have performed relatively better than the rest of the

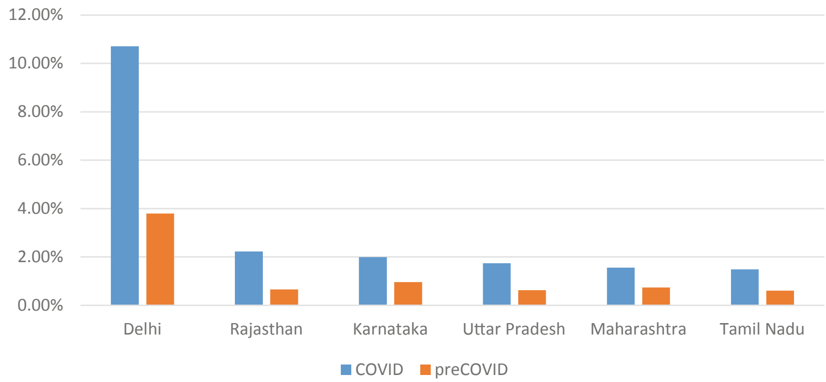

Fig. 6.13 Average % difference from baseline for CO_2 emissions (2020–2025)—COVID-19 impact on e-commerce industry (*Source* Results from the model)

Table 6.10 Summary of key performing states in each scenario

Sr no	*National scenario*	*Key states*
1	National Electronics Policy (Scenario 1)	Andhra Pradesh, Uttar Pradesh, Tamil Nadu
2	Digital India Initiative (Scenario 3)	Karnataka, Delhi, Andhra Pradesh
	COVID impact (Scenario 3.1)	Delhi, Karnataka, Rajasthan[a]
3	National Software Policy (Scenario 4)	Karnataka, Delhi, Tamil Nadu
	COVID impact (Scenario 4.1)	Delhi, Karnataka, Tamil Nadu[b]

Notes [a]The e-commerce industry has had a positive impact during COVID hence show the best performing states
[b]It shows the worst affected states due to the negative impact on software industry
Source Results from the model

regions (Table 6.10). This shows the potential of the southern regions in the manufacturing as well as services sector. Amongst the rest of the states, the positive impact is largely concentrated in Uttar Pradesh and Delhi for Electronics and IT sector policies, respectively. The COVID impact the Digital India Initiative and National Software Policy resulting from e-commerce and software industries, respectively, show that Delhi and Karnataka, the two of the most developed states in India benefit more than the rest of the states.

6.6 Conclusion

The economic reforms of 1991 played an important role in influencing the composition of the growth pattern in India. It has facilitated growth of manufacturing and services with varying degrees. The service sector led by the IT-BPM and telecommunication networking segments have leapt forward by a large margin. Today it contributes 55% to the Gross Value Addition in the national economy whereas the manufacturing sector constitutes less than half of it (PRS, 2020). The world is progressively moving forward towards technological advancement and the need of such goods are getting reflected by the changing demand pattern of consumers. The Electronics Industry and Digital Services have become crucial components of the changing demand and at the same time play an important role in India's growth trajectory. Our study analyses the important policies at the state level for Electronics goods sector and National Software policy along with the impact of Digital India Initiative in regional growth.

Our study shows that the impact of the two IT sector policies, namely the Digital India Initiative and National Software Policy, has a larger and far-reaching impact on the Indian economy compared to the Electronics sector policy. The increase in household income and consumer expenditure has been observed for developed states such as Delhi, Tamil Nadu and Karnataka as well as for less developed states like Uttar Pradesh, Rajasthan and West Bengal, implying an increase in digital penetration and adoption of internet services. This shows positive signal towards more equitable growth in digital services and its adoption at the household level.

The trade analysis of the IT policies revealed that even after the implementation of government IT policies, the sector remains a net importer of software products. In this aspect, the government has put forth a number of supply-side incentives in order to improve the IT infrastructure capacity in the country. But, given these may not influence the trade towards the desired direction, further complementary policies are required. The export-oriented IT industry should also adopt capacity building measures by analysing the changing market dynamics and investing in innovative solutions in order to compete at the global level. Thus, along with promoting mass-scale IT products and services capacity, the quality of end-product should also be focused upon in order to turn India into a net exporter. The government may further provide additional incentives to boost cluster-based growth of IT industries in the underserved states where the firms could have access to better IT infrastructure on rental basis to save the cost.

On the other hand, the Indian Electronics industry is also largely dependent on imports for various components. The supply chain at certain levels was completed by the domestic suppliers as a result of which, we saw an increase in employment levels in the industry. Thus, more rigorous level of localization strategies needs to be adopted in order to produce more indigenous components with the eventual aim of becoming less dependent on imports. The states which are benefitting the most are the already developed states of Andhra Pradesh, Karnataka, Tamil Nadu and Gujarat. In terms of indirect impact, Uttar Pradesh, the largest manufacturer of Electronics products, benefitted the most. Both the state-level policy for electronics and National Electronic policy may have worked together to give a boost to the electronic manufacturing in Uttar Pradesh. It can be seen that the growth of one state may have effect on the neighbouring state as seen in Uttar Pradesh-Delhi growth pattern. Thus, the coordination of the states with the Central government is necessary to boost regional development. Higher transport and communication connectivity would facilitate the spillover effects of growth amongst the neighbouring states. Other states such as Tamil Nadu and Karnataka also see a rise in manufacturing activity in ancillary industries. Thus, with electronics industry showing strong backward and forward linkages in these states as well can also propose electronics policy at the state level to consolidate the positive impact across various sectors. The states which have low manufacturing base may develop the state-level policies along the lines of Uttar Pradesh to attract the manufacturing led growth, given how the electronic industries have huge potential for growth especially in component manufacturing in which India still relies on imports. Another advantage of developing state-level policies is that the focus can be directed towards providing supply-side incentives and utilize domestic resources in indigenous manufacturing and thus become less import dependent across the supply chain.

The negative impact on environment is seen largely for Karnataka, Uttar Pradesh and Tamil Nadu due to the manufacturing in the Electronics industry and ancillary industries. Proper monitoring and adherence to environmental norms and regulations in the respective states should be followed or else the economy will, on an aggregate level suffer due to rising environmental costs.

The COVID-19 scenarios show that the positive impetus gained by the e-commerce industry has benefitted the Trade & Logistics and Hotels & Catering industries due to the adoption of internet services resulting in greater customer outreach as well as reduction in advertisement cost and customer care service costs. It has also specifically helped industries dominated by MSMEs such as Rubber and Plastics, Textiles and Clothing, and Food, Drinks and Tobacco industries. However, the larger adoption of internet services through e-commerce platforms is seen especially for the developed states such as Delhi, Karnataka, Tamil Nadu and Maharashtra. Even though smaller states are benefitted largely through the Digital India Initiative, the process of adaptation is higher in developed states due to the already existing and well-established IT infrastructure along with the availability of skilled workforce. Furthermore, the COVID-19 pandemic is redefining not only our workplace but the means for which internet and various IT services are being used in our day-to-day lives as well. As a result, if special emphasis is not provided to states with lesser IT infrastructure availability, then such policies will run contrary to the objective of inclusive development. The policies must be directed towards the development of digital infrastructure in the backward states through special state incentives and emphasis must be put on skill development. Human capital formation must be done in accordance with the changing need of markets rather than relying on traditional IT services. This would facilitate employment growth along with regional growth in a balanced way which most of the currently developed states are lacking. Thus, the pandemic has unveiled the future of service and manufacturing sector which would largely depend on technology and the level of digital penetration in the country.

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CHAPTER 7

Regional Impact of Automobile Policy in India

Unnada Chewpreecha, Vishnu S. Prabhu, and Kakali Mukhopadhyay

7.1 Introduction

The automobile industry has been at the forefront of sustaining India's rapid economic growth over the last three decades. The economic reforms of 1991 brought significant changes in the Indian economy by abolishing licences and quotas, reduction in import tariffs and increasing Foreign Direct Investment (FDI) which transformed the automobile supply chain. The rise of joint ventures with foreign manufacturers and inflow of capital investment as well as advanced technological equipment rejuvenated the

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auto-component manufacturing segment leading to rapid growth of the automobile industry. As a result, India is today the fifth largest car manufacturer, seventh largest commercial vehicle manufacturer and the largest two-wheeler manufacturer in the world (SESEI, 2018). With the industry's contribution of 7.5% to national GDP (PIB, 2019b) and providing direct and indirect employment to 38 million people (The Hindu, 2019), it was consequently termed as the sunshine industry in recent years and is considered as one of the leading indicators for determining India's economic growth at present as well as in future.

In the past few years, the global market slowdown, coupled with domestic market reforms such as Goods and Service Tax imposition as well as adoption of Bharat Stage-VI (BS-VI) standards for fuel emissions from current fiscal year, has demanded structural changes in the automobile value chain. Under such a challenging economic environment, the government has undertaken an ambitious target of becoming the 3rd largest automobile industry in the world and consequently becoming a leading industry in the promotion of Make in India initiative of the government.

Another initiative which is bound to bring a transformation in the Indian automobile industry is the transition towards Electric Vehicles (EVs). The government has announced the target of achieving 30% electric mobility by 2030 (Shah, 2018) which is aligned with India's Nationally Determined Commitments (NDCs) announced during the Paris Climate Agreement of reducing its emissions intensity to GDP by 33–35% by 2030 as well as the Sustainable Development Goal (SDG) 13, of taking urgent action to combat climate change and its impacts (NITI Aayog, 2018; UNDP, 2020). In this endeavour, the impact of rising EV demand on the electricity sector is also brought into the limelight, as lack of clean energy sources for electricity generation to support EVs can turn out to be counterintuitive to the objective of emissions reduction.

India's efforts towards becoming the 3rd largest automobile industry in the world as well as adoption of EVs has been dented by the unexpected arrival of the COVID-19 pandemic. The subsequent lockdowns and the resulting slowdown in the economy have disrupted the entire set of strategies the government had planned to implement in near future. As a result, India is unable to provide immediate and productive policy responses, resulting in prolonged economic losses and the Indian automobile industry has not been immune from it. This has resulted in unprecedented consequences not only for the industry but also for the national economy.

In the pursuit of achieving multiple targets set for the industry, the contribution of states will differ according to the development strata they belong to and the economic and demographic characteristics they possess. In addition, India has specific automobile manufacturing belts across few states as a result of which, some states will be more receptive to policies impacting automobile industry compared to others. In case of such inter-state disparity, E3-India with its capacity to provide forecasts up to 2035, will be able to capture this heterogeneity across the states. A detailed description of the E3-India model is provided in Chapter 2.

Sections 7.2 and 7.3 discuss the evolution of Indian automobile industry and auto-component industry in India. A comprehensive overview of the rise of Electric Vehicle segment and what economic and environmental changes it is expected to bring is discussed in Sects. 7.4 and 7.5, respectively. Section 7.6 discusses in-depth the scenarios which were built up to assess the region-wise impact of the automobile industry policies followed by findings and discussion in Sect. 7.7 and concluding remarks in Sect. 7.8.

7.2 A Brief Profile of the Automobile Industry

The true potential of the Indian automobile industry began to unravel only after the economic reforms of 1991. Prior to the reforms, the automobile companies produced most of the automobile components in-house as economies of scale supported it. Post-1991 reforms the additional incentive to upgrade and increase the scale of production levels led to the rise of supply chains in the industry. Many foreign manufacturers entered into various Joint Ventures with domestic market players which helped in exchange of technological know-how and upgradation of the supply chain for the auto-components industry. De-licensing, abolishing of quotas and foreign direct investment up to 51% and later up to 100% by 2002 provided a great impetus for the industry to grow rapidly (Singh J., 2014). These major changes set the ground for rapid progress of the industry for the next three decades. Given below is a brief snapshot of the Indian automobile industry.

As shown in Fig. 7.1, between FY18 and FY19, the total production of motor vehicles increased from 29.1 million to 30.9 million with an annual growth rate of 6.2%. The two-wheeler segment is the largest segment

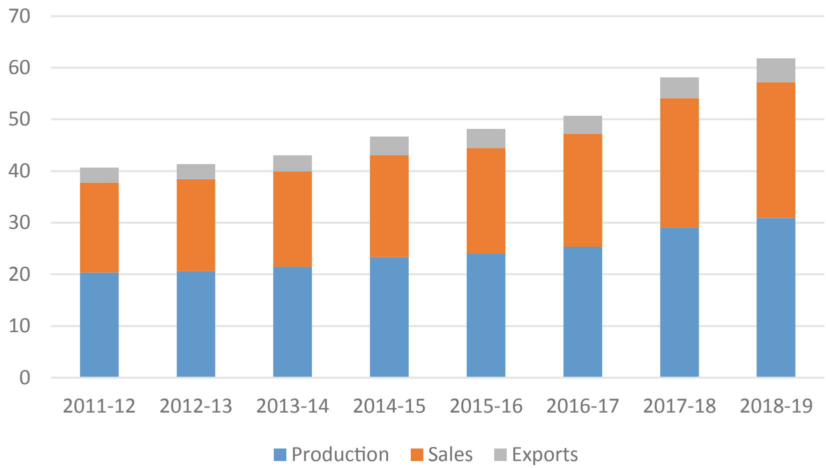

Fig. 7.1 Automobile domestic production, sales and exports between 2014–2019 (in millions) (*Source* SIAM [2019a])

of the motor vehicle industry in India accounting for 79.2%, 80% and 70.8% of total production, domestic sales and exports, respectively, in the fiscal year 2018–2019. Production and domestic sales both have grown at a CAGR of 6% and exports have grown at CAGR 5% in the last five years. India's exports account for 15% of total motor vehicles produced in 2018–2019.

India's exports and imports with top trading partners in 2018–2019 are shown in Fig. 7.2. We can see that more than 20% of total exports are to North America (15.5% USA) due to comparative advantage in low-cost labour for semi-skilled jobs, whereas exports to India's bordering countries such as Bangladesh and Nepal remain minimal at less than 10%. African countries led by South Africa are prime destination for two-wheeler exports. In the case of imports, more than 50% imports are from Southeast Asian countries, with 24% arising from China primarily due to cheaper auto-components. However, the CAGR of exports of auto-components in the last five years has been 11% compared to 7% for imports for the same time period.

India's automobile exports have grown at a very high CAGR of 6% between 2011–2019. In the same time period, India attracted USD 20.85 billion FDI in the automobile industry (PwC, 2019). This is primarily due

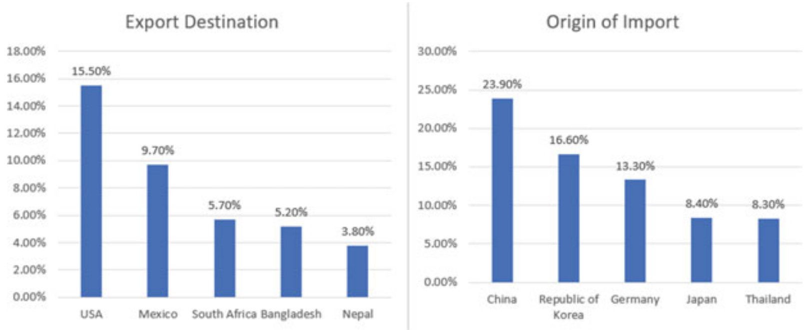

Fig. 7.2 Top five trading countries with India in automobile sector in 2018–2019 (as % of total) (*Source* Trademaps database)

to rapid growth of auto-component industry in India which grew at a faster pace than the automobile industry (further discussion in Sect. 7.3). As of 2018, the motor vehicle penetration in India is 120 per 1000 population and is expected to reach 300 per 1000 by 2028 (SESEI, 2018). With the youngest population and one of the largest middle-income class population in the world, India remains a prime destination for multinational automotive companies.

In this endeavour, the Make in India initiative which aims to promote localization and indigenous component manufacturing has also put special emphasis on promotion of prime automobile manufacturing hubs in India which have been shown in Table 7.1.

Table 7.1 Automobile manufacturing belts across the country

Sr. no	*Region*	*Automobile clusters*
1	East	• Jamshedpur (Jharkhand)—Kolkata (West Bengal)
2	West	• Mumbai-Pune-Nashik-Aurangabad (Maharashtra) • Sanand-Halol (Gujarat) • Pithampur (Madhya Pradesh)
3	North	• National Capital Region Cluster (NCR) • Delhi—Gurgaon (Haryana)—(Uttar Pradesh)
4	South	• Chennai-Bengaluru-Hosur (Tamil Nadu and Karnataka)

Source Make in India (2016)

We can see there are at-least ten states with established automobile hubs constituting 88% of the total automobile manufacturing in the country. These states will play a significant role in leading the Indian automobile industry to become the 3rd largest in the world by 2026.

Along with rapid growth, the technological innovations have continuously evolved in order to remain globally competitive. Governments across the world are becoming more environmentally conscious in forming economic policies as well as the consumer behaviour is shifting towards purchasing products and services which are environment-friendly and energy efficient. Today, India spends approximately 8% of its R&D expenditure in the automotive sector (Bajwa, 2020). The government of India has established the National Automotive Testing and R&D infrastructure Project (NATRiP) with a total funding of approximately USD 532 million which aims to make the Indian automobile industry a globally competitive sector by undertaking testing, validation and creating R&D infrastructure. Along with the two existing facilities in Pune and Ahmednagar cities in Maharashtra in the west, four more greenfield facilities are set up in Manesar, Haryana in the north, Chennai, Tamil Nadu in the South, Pithampur, Madhya Pradesh in the centre and Silchar, Assam in the North-east.

In terms of technological upgradation in the automotive industry, the fuel source used in automobiles has played a crucial role around which the entire automobile assembly line as well as the supply chain has continuously evolved. Currently, there are 3 million vehicles on road running on Compressed Natural Gas (CNG) which is a cleaner source of energy compared to diesel and petrol, saving 3% of fuel consumption in the transport sector which consumes 70% diesel fuel and almost 100% gasoline (SIAM, 2019b). The transport industry accounts for 11% of India's CO_2 emissions (SESEI, 2018), which has increased from 7% in 2008 but nevertheless is lower than the global average of 20%.

Nevertheless, the fuel efficiency of the domestic vehicles has also increased. In the year 2000, the average fuel efficiency of a passenger vehicle was 14.5 kms/lt which gradually increased to 18.2 kms/lt in 2017 (GOI, 2014). The expert committee report on the Auto Fuel Policy 2025 set up by the Ministry of petroleum and natural gas has recommended that the country should now aspire to achieve fuel efficiency of 21 km/l by 2022 (GOI, 2014). India has furthered its bid towards adoption of cleaner fuel sources through the Bharat Stage VI (BS VI) emission standards with effect from April 2020, thus paving the way for cleanest

Table 7.2 Difference in BS IV and BS VI standard specifications

Sr. no	*Fuel type*	*Pollutant gases*	*BS IV*	*BS VI*
1	Petrol passenger vehicle	Nitrogen Oxide (NOx) limit	80 mg	60 mg
2		Particulate Matter (PM) limit	-	4.5 mg/km
3	Diesel passenger vehicle	Nitrogen Oxide (NOx) limit	250 mg	80 mg
4		Particulate Matter (PM) limit	25 mg	4.5 mg/km
5		HC + NOx	300 mg	170 mg/km

Source ACKO (2019)

diesel and petrol variants to be made mandatory across the country for vehicular fuel consumption (Sinha, 2019). This is a shift from BS IV emissions standards as India decided to completely skip BS V standards in its effort towards adoption of cleaner fuel variants. The differences in terms of specifications between BS IV and BS VI are provided in Table 7.2.

The BS VI standards run parallel to the Euro-6 specifications which are also the latest emissions standards adopted in Europe (ICCT, 2016). It took Europe nine years to completely implement the Euro-6 specifications. Thus, it also imposes challenges for the automobile industry in India as the transition towards cleaner fuel variants implies modifications are required in the auto-components segment as well (Embitel, 2018).

Academic literature on the Indian automobile industry shows that its growth story did not begin soon after implementation of 1991 reforms. Sharma (2006) studies the productivity performance of the automobile industry during the period 1990–2004 and explored the determinants which impact the industry in India. The study showed that the productivity levels experienced downfall up to 1995 after which their recovery was seen only during 1995–1998 period. The labour flows increased at a faster rate than capital, implying that the industry experienced labour-intensive growth post-1991. Complementing this study, Ray (2012) using econometric applications find that during the period 1991–2006, the potential capacity building grew at a faster rate than the actual output growth, thus having minimal impact on productivity growth rates and the sale of firms showed positive relationship with capacity utilization. Kumar and Kaur (2016) show that as more multinational auto-companies started played an active role in the Indian economy, the profitability increased with the size of firms, using time series analysis. Vikkraman and Varadharajan (2009) show that the risk-return trade-off amongst the auto-companies showed a high positive correlation, implying that higher risks undertaken by the auto-companies provided large returns for investors and other stakeholders. The resilience of the automobile industry is also demonstrated during the financial crisis of 2009–2010, where Ray (2011) showed using Altman's model that the overall performance during the period 2003–2010, i.e. until the financial crisis of the automobile companies was, even though negatively impacted but still relatively better off. Numerous literature analysing the automobile sector focussed on their national-level performance. However, the analysis at sub-national level is lacking which is very important to understand which regions can contribute with what potential to the automobile sector.

7.3 Brief Profile of the Auto-component Industry

The origin of the auto-component industry in India dates back to the early 1980s, when Maruti (then the largest passenger car manufacturer) decided to procure components from domestic suppliers for the first time (Fintapp, 2017). This led to joint ventures between Japanese and Indian manufacturers for supplying auto-components to Maruti. Prior to this, the industry was a highly protected market with high import tariffs. The components were manufactured in-house by automobile companies as economies of scale supported it. However, with an evolving automobile market in terms of sophistication and technological evolution, the development of auto-component industry became inevitable. The government announced the Phased Manufacturing Programme (PMP) in 1980s to support localization of auto-component market in India (GOI, 2006). The 1991 economic reforms led to liberalization of foreign investment and quotas and licences were abolished. Many foreign manufacturers entered the Indian market through Joint Ventures along with the rise of domestic suppliers. Tier-1 domestic suppliers, i.e. suppliers which directly provide components to car manufacturers began its operations for the first time in India, post-1990. Foreign car manufacturers started importing its supplies at first, but with time as domestic suppliers internalized the technological know-how, they started procuring locally. Thus, the 1991 reforms proved to be foundation of the auto-component industry in India as it provided a tremendous boost to its development in the country.

As of 2018–2019, the auto-component industry in India has a turnover of USD 57 billion contributing 2.3% to the National GDP and providing employment to approximately 5 million people (ACMA, 2019b). The component-wise breakup shows that the largest share is of engine components (25.9%), followed by Suspension and Braking (16%), Body/Chassis (14%), Drive Transmission and Steering (13.3%) and Electrical and Electronics (12.4%).

The auto-component industry has grown at a CAGR of 13% while the automobile industry witnesses a CAGR of 8% (Fintapp, 2017). This has been primarily due to reduction in auto-component import duties making it a highly competitive market and increasing the quality standards of the products for domestic sales as well as for exports. The exports peaked at USD 15.16 billion in 2018–2019 which constitute 4% of total exports. A trade snapshot of the Indian automobile components industry is provided in Fig. 7.3.

We can see from Fig. 7.3 that imports have historically been higher than exports in the industry. However, this trade deficit has come down in successive years as the CAGR of exports has been 11% compared to 7% for imports between 2013–2019 (ACMA, 2019a). One of the factors in the growth of exports has been due to the cost-effectiveness achieved by the industry as a result of availability of cheap labour. The wage costs in the auto-component manufacturing account for 3.15% of sales in India, compared to 20–40% for manufacturers in USA and 10–25% in Europe

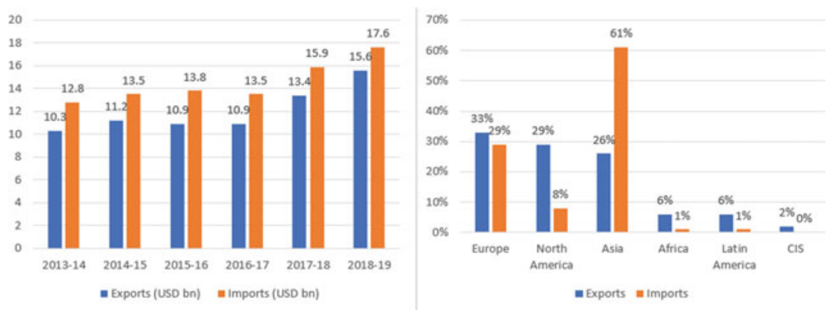

Fig. 7.3 Total exports and imports of auto components along with the share of export and import markets (2013–2019) (*Source* ACMA [2019b])

and Latin America (Fintapp, 2017). India's prime destination for exports has been Europe, led by Germany (7%) and UK (5%) as well as North America which has predominantly been USA (25%), which is also the single largest export destination. The origin of imports has been coming from China (27%) on a large scale due to cheaper value followed by South Korea (10%), Japan (9%) and ASEAN member countries as well.

The auto-components suppliers are categorized into three tiers. Tier-1 suppliers assemble the final components and supply it directly to the Original Equipment Manufacturers (OEM), Tier-2 suppliers provide the sub-components to Tier-1 suppliers and Tier-3 suppliers provide to Tier-2 and Tier-1 suppliers (Dhawan et al., 2018). 74% of the total sale comes from the Original Equipment Manufacturers and the rest 26% from the replacement market or the aftermarket (Fintapp, 2017). The OEMs falls under the organized sector whereas the aftermarket/replacement market falls in the unorganized sector (IBEF, 2020).

One of the targets is to promote indigenous components for the Indian automobile sector. The industry has also adopted rigorous localization strategies in order to become less dependent on imports for its supplies. This is shown in Table 7.3.

As we can see, the Tier-1 suppliers to OEMs have achieved almost 100% localization levels in all the segments of the automobile industry. As a result of 100% FDI allowed in the sector, the import of technical know-how as well as high quality capital-intensive equipment from abroad has assisted in the industry's transition towards high levels of localization. Between April 2019 and March 2020, the sector received investment through the FDI route of USD 24.21 billion (IBEF, 2020).

In order to remain competitive in the global market, the auto-component industry needs to become more efficient in its operations.

Table 7.3 Tier 1 suppliers' localization levels

Sr. no	*Auto-component segment*	*Avg. localization (%)*
1	Hatchbacks, compact sedan/SUVs	90–95
2	Premium sedans	85–90
3	Commercial vehicles	>90
4	2-wheelers	>90
5	Tractors	>95

Source Fintapp (2017)

Between 2012–2016, 2.2 million vehicles were called back from across the world due to faulty/defective components (Dhawan et al., 2018). This has made the industry more alert regarding the quality standards of its products in order to remain competitive in the global market. Furthermore, the transition towards EVs will also bring about an overhaul of the auto-components industry with the share of auto-electronics to nearly 45% of the total automobile cost (Dhawan et al., 2018). The structural changes which the EVs will bring in the assembly line of auto-component suppliers is explained further in the next section.

7.4 The Evolution of EV Segment Policies in Recent years

The first time policy-makers in India emphasized the promotion of Hybrid/Electric Vehicles (EV) was in the Automotive Mission Plan 2006–2016 (Miglani, 2019). The policy stated the importance of R&D facilities for supporting alternative cleaner fuels as well as encouraging indigenous manufacturing of hybrid engines in India. However, the policy neither put forth any roadmap, nor any monetary allocation to stimulate the growth of the EV segment. As EVs were being crowded out of the larger automobile policy framework due to its negligible share in the total motor vehicles segment in India, the government in 2012 came up with the National Electric Mobility Mission Plan (NEMMP) 2020 (GOI, 2012). This was the first policy specifically focusing on the EV segment in India. The report set a target of achieving 6–7 million sales of electric and hybrid vehicles by 2020, with the larger goal of achieving energy security and curbing environmental pollution. The three major aspects of the policy were, (a) demand creation by providing subsidies on EV purchase by the end consumers, (b) supply incentives such as tax rebates/deductions for OEMs and (c) improve charging infrastructure across the country to stimulate EV penetration across the country.

The major policy initiatives provided in NEMMP were executed through its sub-policy, namely Faster Adoption of Manufacturing of (Hybrid) Electric Vehicles (FAME). The 1st Phase of FAME (FAME I) came in effect from 1 April 2015 and remained in operation till 31 March 2019 with a fund allocation of USD 75.5 million (PIB, 2019a). During these four years, the government supported 280,000 EVs through various demand incentives which constituted more than 65% of the total funds allocated.

On 1 April 2019, FAME 2nd Phase (FAME II) was announced which will remain operational till 31 March 2022. The total outlay for FAME II was USD 1.42 billion which is a phenomenal increase compared to the outlay of INR 529 crores allotted to FAME I (PIB, 2019c). With increased fund allocation, the government has also set ambitious target of achieving sale of 10 lakh e-2 wheelers, 5 lakh e-3 wheelers, 55,000 e-4 wheeler passenger cars and 7000 e-buses. The demand incentives provided under this scheme is linked to the battery capacity, which is USD 142.8/KWh, except for e-buses which is USD 285.7/KWh (PIB, 2019c). Furthermore, the government has sanctioned 2,636 charging stations across the country amounting to USD 71.4 million in 62 cities (PIB, 2020a, b). During the inception of the Goods and Services Tax (GST) in 2015, the tax of EVs was in the highest tax slab of 28% which has been now reduced to 5% (PIB, 2020b). This has provided an additional stimulus for sale of EVs across the country. The EV sales during FAME Phases I and II are provided in Table 7.4.

In FAME I and II, the top ten states constitute 78% and 85% of the total EV sales, respectively. In FAME Phase I, 500 charging stations were sanctioned across the country, of which 295 charging stations have been installed (PIB, 2019c) and 425 hybrid/electric buses were sanctioned in various cities (PIB, 2020b). In FAME Phase II, Karnataka tops the

Table 7.4 Top 10 states with the highest EV sale in numbers during FAME I (2015–2019) and FAME II (2019–2020)

	FAME Phase I (2015–2019)		*FAME Phase II (2019–2020)*	
Sr. no	*States*	*EV sales*	*States*	*EV sales*
1	Maharashtra	36,708	Karnataka	6226
2	Gujarat	31,577	Tamil Nadu	2946
3	Uttar Pradesh	28,985	Maharashtra	2675
4	Haryana	25,908	Delhi	1926
5	Delhi	20,228	Uttar Pradesh	1850
6	Karnataka	15,526	Bihar	839
7	Tamil Nadu	17,901	Rajasthan	757
8	Rajasthan	17,405	Chhattisgarh	590
9	West Bengal	14,775	Telangana	537
10	Kerala	11,394	Madhya Pradesh	520
11	All India	280,987	All India	22,173

Source Ministry of Heavy Industries and Public Enterprises, GoI (2020) list with the highest EV sales during the FAME II phase. The top ten states constitute 85% of the total EV sales in 2019–2020. The relatively poorer states of Uttar Pradesh and Bihar have seen a rise predominantly due to the sale of e-rickshaws which has the highest share in the respective state's total EV sales. This is because sale of e-rickshaws has been monetarily supported by the respective state governments. On the other hand, the developed states of Karnataka and Maharashtra are amongst the top then states in FAME II phase as well due to their active pursuit of EV component manufacturing and promoting purchase of EVs amongst end consumers by providing various demand-side incentives. Karnataka was actually the first state in India to launch State-EV policy in 2017 after which many other states followed. Under Phase II, of the 2,636 eV charging stations sanctioned, Maharashtra has the highest allocation, with 317 stations, thus encouraging consumers to purchase EVs due to infrastructural support. Delhi is another region which is actively promoting EVs with providing charging stations every 3 kms in the National capital Region (Singh A., 2020). The energy and environmental impact of the policies is shown in Table 7.5.

Another major initiative launched by the government was the 'Urban Green Mobility Scheme 2017' under the Ministry of Housing and Urban Affairs, Government of India, which is complementary to the Smart City Mission (UITP, 2017). Unlike FAME, which focussed on sale of EVs to the end consumer, in this scheme the government itself wants to take the lead by initiating transition towards electric mobility by promoting e-buses for public transport. The government aims at procuring at least 6000 buses based on alternative fuels/electric in 103 cities (5 million + population and state capitals) across the country by 2023. The total budget allocation for this scheme has been USD 10 billion.

Table 7.5 Estimated fuel saved (in litres) and CO_2 emission reduction (in kgs) during FAME Phase I (2015–2019) and FAME Phase II (2019–2020)

Sr. no		*FAME phase I*	*FAME phase II*
1	Estimated fuel saved (in litres)	67,323,133	5,884,289
2	Estimated CO_2 reduction (in kgs)	167,621,002	13,392,264

Source Ministry of Heavy Industries and Public Enterprises, GoI (2020)

NITI Aayog, India's leading policy think-tank predicts that the current set of initiatives supporting the EV segment in India as well as the government's focus towards cleaner fuels will lead to 40% of the total private vehicles in the country consisting of purely electric vehicles (Juyal et al., 2017) and the rest 60% will be hybrid vehicles leading to savings of 64% energy demand and 37% reduction in CO_2 emissions in 2030 (SIAM, 2017). Furthermore, the current government has also set an ambitious target of making India the number one destination for EV manufacturing (Mishra, 2019) for which a Phased Manufacturing Programme (PMP) has been initialized for localization of battery cells and packs and EV components such that the entire EV assembly line can be manufactured locally by 2023–2024 (Drishti, 2019). With this intent, ten states have come up with EV policies so as to support EV manufacturing and penetration in the state. These will be discussed in detail later in Sect. 7.6.

7.5 Technical and Financial Challenges to EV Transition

Overall, it is fair to say that the government over the last decade has been very proactive in terms of using various policy instruments for supporting the EV segment of the Automobile Industry. However, there are still certain shortcomings which need to be addressed. Currently, even with a slew of policy measures, the EV penetration has been at a sluggish pace because the cost of EVs is still 2–2.5 times higher than a conventional Internal Combustion (IC) Vehicles (SIAM, 2017). The availability of charging stations is still highly disproportional to the expected EV consumers. The battery cells and packs are the most important part of an electric vehicle constituting almost 50% of the total cost (Fuchs et al., 2014; GOI, 2012). In Table 7.6 a comparison of electric vehicle and the conventional combustion vehicle in terms of component-wise share of value addition is provided.

As we can see, the battery pack is the costliest component of an electric vehicle. We can also see that requirement of other components is also to a lesser magnitude compared to IC vehicles which also leads to relatively lower maintenance costs of an EV over its lifetime. In India, the Lithium ion (Li-ion) batteries which are used in EVs is largely imported from China, Japan and South Korea (Drishti, 2020a). The cost of imports of Li-ion batteries increased from USD 370 million in 2006 to USD 930 million in 2019. The rise in imports has been primarily due to the

Table 7.6 Cost structure of an electric vehicle and a conventional vehicle

Sr. no	*Component*	*Electric vehicle (%)*	*Conventional internal combustion vehicle (%)*
1	Battery pack	35–50	–
2	Chassis	4–9	9–12
3	Vehicle body	7–19	11–20
4	Drivetrain	8–20	22–24
5	Equipment	22–24	30–37
6	Other	5–15	15–20

Source Fuchs et al. (2014)

increased demand for EVs. The demand for battery cells is set to reach 10 GWh by 2022 and 50 GWh by 2025 (NITI Aayog, 2018). Due to lack of mass scale battery manufacturing in the country, the overall cost of EVs relative to the conventional vehicles remains high primarily due to the large imports of Li-ion batteries. In order to ease the cost burden on the consumers, the government has allowed the delinking of sale/registration of electric vehicles from batteries which implies that the EV battery packs can be bought separately either from the same original equipment manufacturer or from separate energy service provider (Gupta, 2020). Nevertheless, this is only a short-term solution whereas only mass scale battery production in the long term can help EVs achieve cost parity with conventional vehicles.

With promotion of EVs, these emission levels are expected to come down further as they substitute internal combustion vehicles. However, with increase in electricity demand, the source from which electricity is generated will also be an important aspect to gauge as thermal fired power plants incur other kinds of emission[1] (Guttikunda & Jawahar, 2014; Juremalani & Nihalani, 2018). As of July 2020, the installed capacity from thermal power sources (Coal, Diesel, Lignite and Gas) constitute 62% of the All-India capacity (CEA, 2020) which can imply that a decrease in one group of emissions from the transportation sector can be substituted by another group of emissions in the power sector as a result of electricity demand. An interim report by Pachouri and Saxena (2020)

[1] Sulphur Trioxide (SO_3) and Sulphur Dioxide (SO_2), Ash, Nitrogen oxides (NO_2) Mercury (Hg^{++}, Hg0) and Carbon Monoxides (CO) and Particulate Matter ($PM_{2.5}$).

shows that emissions from coal fired power plants in India could lead to premature deaths of 77,000 people in 2020 with an associated cost of USD 10 billion. Thus, higher levels of electricity generation from thermal power plants can also lead to increase in the negative health impacts in the society.

Furthermore, Knobloch et al. (2020) show using the E3ME-FTT-GENIE model that based on the electricity mix for 2015 the EV penetration within the country will also be complemented with increase rather than decrease in CO_2 emissions. The authors also provide segment-wise emissions which show that increase in electricity usage leads to larger CO_2 emissions compared to increase in EV battery production or car production within the country. With the current rate of adoption of Renewable Energy Sources (RES) for electricity generation, the impact of EVs will broadly remain neutral in 2030 but can improve with faster RE capacity building. Thus, the government's aim of achieving 30% electric mobility by 2030 will have a positive or negative environmental impact largely depending upon how the power sector will revise its energy mix.

However, the complementary transition in power sector is plagued with technical and structural obstacles. The power distribution companies (Discoms) are mired with a bulging USD 20 billion debt even after frequent bailouts by the state and central governments and the existing poor quality power infrastructure leads to periodic load shedding and fluctuating power load even in the metropolitan cities in India (Dixit, 2020). This raises concerns regarding the quality of power supply expected at various public charging stations. Even in developed countries such as Canada and Germany which are far ahead in the growth of EV market, the biggest resistance to EV adoption is what is termed as 'range anxiety' which is the lack of confidence in the availability of not only good quality power supply for saving charging time but also regarding the frequency of public charging stations over long distance journeys (Brody-Moore et al., 2020; Walsh & Singh, 2020). Singapore which has set a target of phasing out IC vehicles completely by 2040 has also planned to substantially expand its public EV charging capacity from 1,600 to 28,000 charging points across the country (Doshi & Zahur, 2020). This provides an indication of not only the frequency of charging stations but also the intensity of power supply required across India in order to achieve smooth transition towards electric vehicles in the automobile industry.

In the next section, we discuss the national and regional level automobile sector scenarios prepared on the basis of the current operational automobile and EV policies in the country. With the help of E3-India model, we evaluate the impact of these scenarios at the regional level across various economic parameters.

7.6 Development of Scenarios—National and Regional Policies

In this section, we discuss the national and regional level policies w.r.t the Indian automobile industry.

7.6.1 Policy 1: Automotive Mission Plan 2016–2026 (AMP 2026)

The automotive mission plan 2016–2026 (AMP 2026) is the collective vision of various stakeholders in the industry such as Original Equipment Manufacturers (OEMs), auto-components manufacturers, technology and R&D development, traders, automotive dealers, exporters and buyers for making the Indian automobile industry the 3rd largest in the world by 2026. AMP 2026 also contributes towards the government's marquee programmes which are the 'Make in India' initiative for promoting indigenous manufacturing, 'Skill India' to generate large number of jobs in the economy by providing them the necessary soft skills to remain competitive in the labour market and 'Atmanirbhar Bharat Package'[2] which aims at making India self-reliant in key economic sectors (DHI, 2016; PIB, 2020a). AMP 2026 will not only benefit the automobile industry but is expected to significantly impact various sectors of the economy[3] (DHI, 2016) which have been analysed in this chapter.

In this endeavour, individual states will play a significant role such that the aggregate contribution of states will provide a great impetus in reaching the national goal for the automobile industry.

I. **Scenario 1.1—Automobile output**: *Increase in state-wise output growth rates to achieve the automobile industry target of USD 300*

[2] For further details refer to Chapter 10.

[3] These include industries such as automotive electronics, light-weighting materials, moulds and dies, machine tools, iron and steel, aluminium, lead, rubber, plastics, glass, and capital goods as well as services such as logistics, banking and insurance, sales and distribution, services and repair and fuels.

billion by 2026 in order to become the third largest automobile industry in the world.

The annual turnover of the Indian automobile industry was USD 100 billion in 2020 (EtAuto, 2020a). Thus, the aggregate contribution of all states will play a significant role in achieving USD 300 billion, implying an increase of USD 200 billion between 2020–2026. The top ten states constituting the leading automobile manufacturing belts in the country will be at the forefront of achieving this target. The share of gross output expected to contribute in the AMP 2026 target is shown in Table 7.7.

The ten states constitute 88% of the total motor vehicles manufacturing in the country. This implies of the additional USD 200 billion turnover by 2026 (compare to 2020), USD 176 billion will come from the ten automobile hubs mentioned in Table 7.7.

II. **Scenario 1.2—Auto-component output**: *Increase in state-wise output growth rates to achieve the automobile component segment target of USD 116 billion by 2026.*

The annual turnover of the auto-component segment was USD 57 billion in 2019. AMP 2026 has set a target of achieving turnover of USD 116

Table 7.7 State-wise automobile industry's output targets (2020–2026)

Sr. no	*States*	*Share (in %)*	*Share (in USD million)*
1	Tamil Nadu	26.25	52,495
2	Haryana	22.00	44,004
3	Maharashtra	19.74	39,476
4	Karnataka	7.68	15,370
5	Uttar Pradesh	3.80	7,594
6	Jharkhand	3.39	6,770
7	Gujarat	2.76	5,529
8	Madhya Pradesh	2.18	4,369
9	West Bengal	0.11	228
10	Delhi	0.11	211

Source EPWRF database—Gross output 2017–2018; Make in India (2016)

Table 7.8 State-wise auto-component industry's output targets in (2020–2026)

Sr. no	*States*	*Share (in %)*	*Share (in USD million)*
1	Maharashtra	20.6	12,130
2	Haryana	18.0	10,626
3	Tamil Nadu	14.3	8,457
4	Karnataka	8.8	5,213
5	Uttar Pradesh	3.0	1,764
6	Gujarat	1.4	849
7	Madhya Pradesh	0.3	185
8	Jharkhand	0.2	109

Source EPWRF database

billion by 2026, implying an increase of USD 59 billion between 2020–2026. The share of gross output of auto-component manufacturing in the top eight automobile hubs is shown in Table 7.8.

The 8 states together constitute 66.7% of the total auto-component industry in the country implying that of the additional USD 59 billion turnover, USD 39.4 billion will be achieved by the eight states shown in Table 7.8.

III. **Scenario 1.3—Auto-component exports**: *Increase in state-wise output growth rates to achieve the automobile component sector exports of 35–40% of overall output.*

AMP 2026 aspires to achieve exports which will account for 35–40% of the total output by 2026, compared to 27% on 2016. Based on the average growth rate of the auto-component exports between 2006–2017 for the top six states in auto-component industry, we provide an additional 5 percentage point growth target as per the individual state potential.

The average annual growth rate of exports of top eight states along with their targets is shown in Table 7.9.

IV. **Scenario 1.4—COVID Impact**: *The automobile industry is expected to grow at 9% CAGR in COVID scenario compared to 11% in pre-COVID scenario between 2020–2026 expected in Scenario 1.1 (S1.1)*

Table 7.9 State-wise auto-component industry's exports targets (2020–2026)

Sr. no	*States*	*Average annual growth rate (2006–2017) (in percentage)*	*Targeted annual growth rate (2020–2026) (in percentage)*
1	Gujarat	9.1	14
2	Haryana	13.4	18.5
3	Jharkhand	9.5	14.5
4	Karnataka	19.8	25
5	Maharashtra	15.9	21
6	Tamil Nadu	18	23
7	Uttar Pradesh	12.6	17.5
8	Madhya Pradesh	17.4	22.5

Source E3-India model

Due to the COVID-19 pandemic, the automobile industry is losing on an average USD 2 billion monthly according to Confederation of Indian Industry (CII) (ETAuto, 2020b). During this period the Original Equipment Manufacturers (OEMs) cut down their production by 18–20% as a result of which at least 286 auto dealers were closed and job losses not only for the OEM category but also for the downstream activities (auto-component and auto-dealerships) is estimated to be 3,45,000 across the country (Parliamentary Standing Committee on Industry, 2020). Unless the situation drastically changes, the automobile industry is expected to return to its normal growth trajectory post-2022 (Deloitte, 2020). As a result, the industry's growth is expected to drop from 11% CAGR in pre-COVID scenario expected in Scenario 1.1 (S1.1) as per AMP 2026 to 9% in the COVID scenario.

7.6.2 Scenario 2: Tamil Nadu auto-component manufacturing:

Tamil Nadu auto-components output is expected to increase to USD 40.6 billion in 2026, from USD 13.3 billion in 2016, a CAGR of 12%.

Tamil Nadu is one of the leading automobile manufacturing and export hubs in the country (IACC, 2017). It accounts for 35% of India's auto-components production with 22% constituted in the capital city of Chennai Govt. of Tamil Nadu (2014). The state also has one of the busiest seaports of the country in Chennai, thus gaining an edge for exporting auto-components products as well. Complementing AMP 2026 as explained in Scenario 1, the output of Tamil Nadu auto-component industry is expected to grow at a CAGR of 12% between 2020–2026.

7.6.3 Scenario 3: State electric vehicle policies

The Government of India has set a target of achieving 30% electric mobility of the total motor vehicle mobility in India by 2030 (Shah, 2018). This initiative is also aligned with India's NDC in the Paris Climate Agreement of achieving 30–35% reduction in emissions intensity to GDP by 2030 and SDG (13) of taking actions to tackle climate change (NITI Aayog, 2018; UNDP, 2020). For this purpose, it has been observed that India has adopted a more decentralized approach where the state governments are determining the direction they want to undertake to encourage EV transition. There are currently eleven states with proposed/operational EV policies of which seven EV policies have been provided monetary allocations and employment targets (ACMA, 2020). These seven state-EV policies have allocated monetary support not only for increasing EV fleet and employment generation in the transport sector, but also to promote EV and EV equipment manufacturing as well. The battery-cell manufacturing constituted the largest share in the manufacturing of EVs (Fuchs et al., 2014). In Fig. 7.4, the monetary share of EV components is provided based on which the state-wise EV policy targets are segregated as well.

The seven state-wise policies along with their respective targets are shown in Table 7.10.

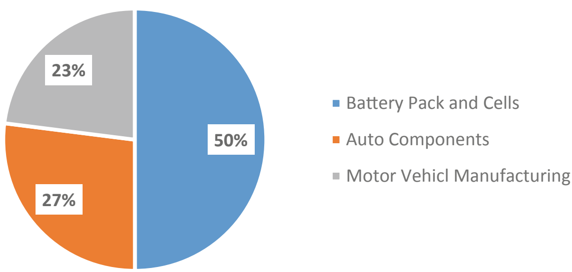

Fig. 7.4 Disaggregation of monetary targets for EV component manufacturing (in percentage) (*Source* Fuchs et al. [2014])

Table 7.10 EV policies across the states in India

Sr. no	*State*	*Scenarios*	*Time period*	*Variable*	*Target for the final year (in USD million for investment in % for output and in numbers for employment)*
1	Uttar Pradesh	3.1	2019–2024	Investment	5,714
				Employment	50,000
2	Maharashtra	3.2	2018–2023	Investment	3,571
				Employment	100,000
3	Delhi	3.3	2020–2024	Output	40% per annum
4	Karnataka	3.4	2017–2022	Investment	4,428
				Employment	55,000
5	Bihar	3.5	2019–2024	Investment	214
				Employment	50,000
6	Kerala	3.6	2018–2023	Output	53% per annum
7	Andhra Pradesh	3.7	2018–2023	Investment	4,285
				Employment	60,000

Notes The investment targets for respective states was provided in INR which was converted into USD with the exchange rate USD 1 = INR 70
[a]EV Reporter (2019); Govt. of Maharashtra (2018); Government of NCT of Delhi (2020); Govt. of Karnataka (2017); Govt. of Kerala (2019); Govt. of Andhra Pradesh (2018)
Source State-government EV policy reports[a]

Different states have set different timelines for the implementation of their respective EV policies, however, we look at the comparison of how the states will perform in the long run till 2030 across various parameters.

In the following section, the results of all the scenarios discussed are provided.

7.7 Results and Discussions

The results of the policies using E3-India model are discussed broadly with three different impact analyses. The macroeconomic impacts show the result of the scenario-wise results for various macroeconomic variables, followed by the indirect impact which discusses the sectoral changes in the regional economies resulting from the respective scenarios and finally the environmental impact under different scenarios.

i. **Macroeconomic impacts**

The execution of AMP 2026 Scenarios 1.1–1.3 by the central government shows varying results across the states. The contribution towards state-GDP over the baseline is highest in Tamil Nadu (1.14%) and Haryana (1.4%) for the automobile scenario (S1.1) and in Gujarat (1%) and Haryana (0.8%) for auto-component scenario (S1.2). Tamil Nadu has long been considered as the manufacturing hub of India, hosting a number of global automobile-MNCs and providing world-class facilities. AMP 2026 is primarily supply expansion policy hence the modelling results reflect changes associated with sector expansion across the supply chain in the domestic market as well as through imports. The contribution of Haryana and Tamil Nadu towards their respective state-GDP is also the highest relative to other states which shows the strong backward and forward linkages leading to output expansion across various sectors. E3-India shows the impact on GDP through the value-added method, hence majority impact resulting from sectoral changes in intermediate demand is not reflected in % difference from baseline for GDP. The supply chain of Haryana and Tamil Nadu which have benefitted the most as a result of the policy is highly dependent on inter-regional and international imports with 9 and 5.7% increases over baseline for Haryana and Tamil Nadu, respectively. States such as Maharashtra, Gujarat and Karnataka have also shown robust increases in imports in various stages of the supply chain. In auto-component exports (S1.3), we see Tamil Nadu by far is ranked the highest for exports vis-à-vis the baseline with 10% increase followed by Haryana and Karnataka.

The increase in imports is also induced due to the rising consumer demand and spending. Tamil Nadu and Haryana show the highest increase in consumer expenditure whereas the smaller states of Jharkhand and Madhya Pradesh show minimal increase from baseline in the automobile scenario (S1.1). In acquisition of technology for innovative purposes, Tamil Nadu is ranked one of the largest recipients as private multinational automobile companies opt for technology transfer from abroad thus, increasing imports (NSTMIS, 2014). All the states show robust increase in employment levels as well, resulting in increased household income which is translated into increase in consumer expenditure. Haryana shows the highest increase in employment, a 12% in the automobile scenario and a 2.8% in the auto-component scenario. The resulting impact from auto-component exports is minimal for all states. Gurugram, the capital of Haryana has turned out to be a manufacturing and tertiary sector hub as a result of its connectivity with the National Capital Region (NCR) which is a hotspot for various economic activities, supporting the tremendous growth of Haryana as automotive hub. The summary of the macroeconomic indicators for AMP 2026 scenarios is given in Fig. 7.5.

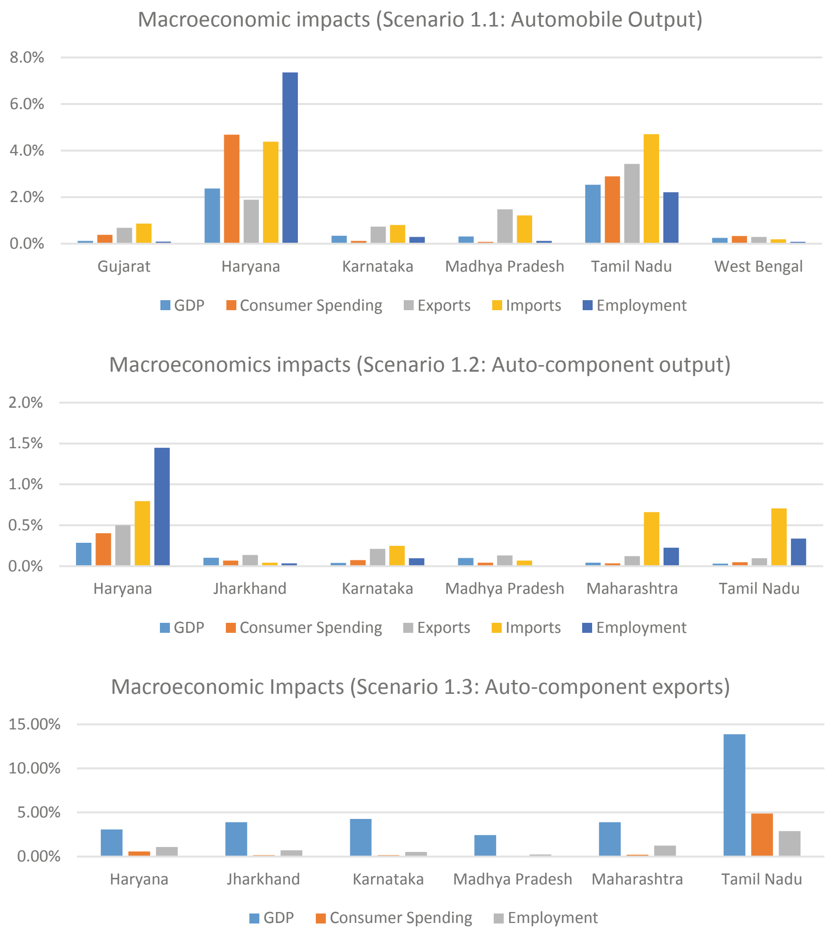

Fig. 7.5 Macro-economic indicators (average % differences from baseline between 2020–2026)—AMP 2026 (*Source* Results from the model)

The COVID-19 impact on the automobile industry also shows significant impact on almost all the major automobile hubs in India. We can see from Fig. 7.6 that all the major automobile manufacturing states of Tamil Nadu, Karnataka and Maharashtra suffer due to the lockdown imposed due to the pandemic.

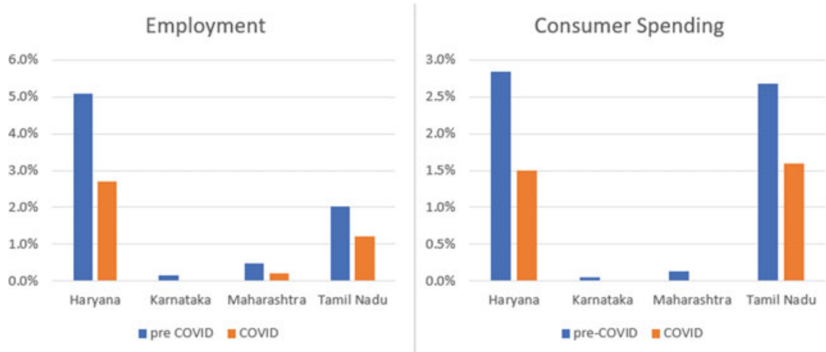

Fig. 7.6 Employment and consumer spending (average % differences from baseline between 2020–2026)—COVID-impact: Automobile output (*Source* Results from the model)

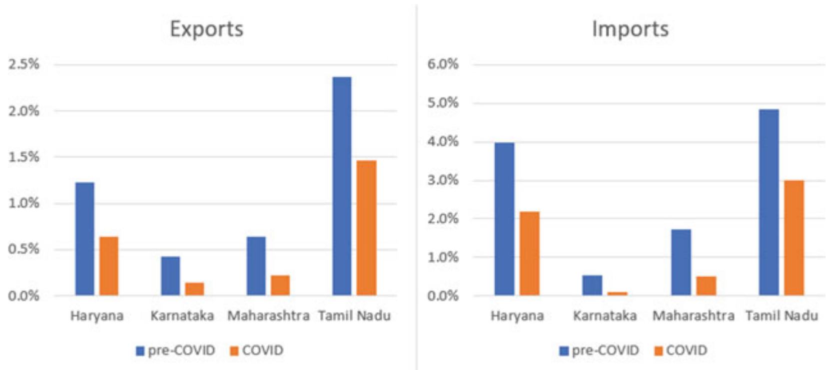

Fig. 7.7 Exports and imports (average % differences from baseline between 2020–2026)—COVID-impact: Automobile output (*Source* Results from the model)

The resulting impact on the entire supply value chain is also seen where the imports and exports turn negative or see a sharp fall for various states (Fig. 7.7). It should be noted that this COVID scenario focuses only on the automobile industry and its implication to wider economy. It does not capture the full COVID impacts which would result in more severe GDP and jobs reduction.

The macroeconomic impact of the state-level policy for Tamil Nadu (Scenario 2) also shows the same impact as that of the AMP 2026. Due to the large capacity for manufacturing in various sectors, it was termed as the 'Detroit of the East'. The ecosystem of Tamil Nadu has encouraged various industries to make manufacturing in Tamil Nadu a significant part of their Global Value Chains as well. This led to increasing integration of the auto-component industry regionally as well as internationally (Fig. 7.8).

The state remains a significant net importer as a result of increase in auto-component manufacturing. However, it also leads to increase in exports as well, implying that the Tier-1 and Tier-2 auto-component suppliers produce domestically as well as import various other components. It also shows positive impact on all other macroeconomic indicators as well.

The overall impact of State-EV policies (Scenario 3) shows that Karnataka is leading this transition in the automobile industry. Karnataka was also the first state in India to bring an Electric Vehicle policy at the state level. Other states which show significant contribution over

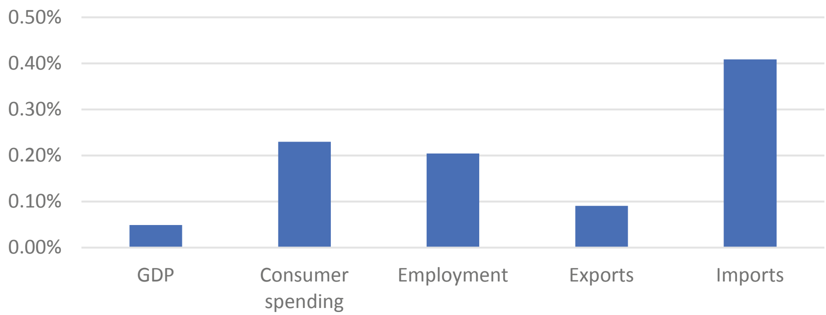

Fig. 7.8 Macroeconomic indicators (average % differences from baseline between 2020–2030)—Tamil Nadu auto-component manufacturing (*Source* Results from the model)

the baseline scenario are Uttar Pradesh, Maharashtra, Tamil Nadu and Delhi. As explained before, for the manufacturing of EVs the Battery pack and cells play a significant role. Thus, the states with a strong base for electronics industry will excel more than the other states due to the existing ecosystem for battery manufacturing. Uttar Pradesh, Maharashtra have the highest impact on battery manufacturing whereas Karnataka leads in the rest of the segments. The impact on component-wise EV manufacturing is shown in Fig. 7.9.

The significant investments provided by the states with the objective of employment generation also lead to increased disposable household income in various states. However, the magnitude of increase is small as the EV industry in India is still at a very nascent stage. Hence its outreach is not to the extent which the conventional automobile industry has and this is the same reason why its contribution to GDP and consumer spending is minimal as well. The top three states with the highest increase in household income are Delhi (0.48%), Karnataka (0.14%) and Andhra Pradesh (0.11%).

ii. **Inter-sectoral impact**

As a result of the state-level and national level automobile policies, the inter-sectoral impacts across states also show some interesting results. For the AMP 2026, the automobile scenario (S1.1) shows that the various

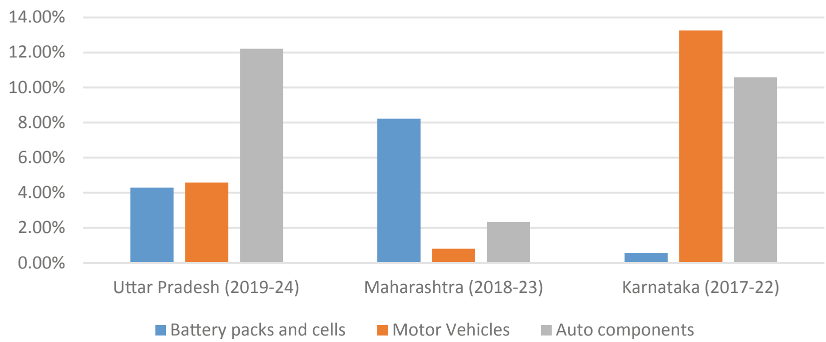

Fig. 7.9 EV component manufacturing outputs (average % differences from baseline between given years)—state EV policies (*Source* Results from the model)

sectors in relatively smaller states from the point of view of the development strata they belong to show a significant improvement. This is because the ancillary industries in these states supporting the automobile assembly line received a positive impetus for output growth. Sectoral results suggest supply chains will benefit from shocks to other transport equipment/motor vehicle output, e.g. electronics, basic metal/metal products other mining (materials) and other manufacturing (parts) benefit from these automobile policies (Table 7.11).

Table 7.11 Indirect output and employment impacts (average % differences from baseline between 2020–2030)—AMP 2026

Sr. no	*Sector*	*State*	*Output (%)*	*Employment (%)*
1	Basic metals	Haryana Tamil Nadu Uttar Pradesh	Above 10	Below 5
2	Metal goods	Haryana Tamil Nadu Jharkhand	Above 25	12–18
3	Manuf. fuels	Haryana Jharkhand Uttar Pradesh	5–20	Below 3
4	Chemicals	Jharkhand Tamil Nadu Karnataka	Below 25	12–18
5	Electronics	Haryana Jharkhand Gujarat	5–30	5–25
6	Electrical equipment	Maharashtra Karnataka Gujarat	11–16	Below 5
7	Other transport equipment	Jharkhand Madhya Pradesh Gujarat	Below 5	Below 5
8	Leather	Maharashtra Gujarat Madhya Pradesh	Below 2	Below 2
9	Rubber and plastics	Tamil Nadu Maharashtra Karnataka	Below 15	Below 2

Source Results from the model

As we can see, the states of Madhya Pradesh, Gujarat, Uttar Pradesh and Jharkhand which also have automobile hubs as defined by the Make in India initiative may not be directly benefited from policies as we saw in the previous sub-section, but its indirect impacts across different sectors have played a significant role. The Basic Metals, Metal Goods and Manufacturing Fuels industries are dominant in the sates of Jharkhand and Madhya Pradesh due to the presence of various mining activities as well as heavy machinery industry. The Rubber and Plastics industry sees a significant increase in Uttar Pradesh as well as in Maharashtra due to the large presence of MSMEs in the state.

For Tamil Nadu state policy (S2), the industries which are positively impacted in Tamil Nadu as a result of the state policy are Electrical Equipment, Metal goods, Chemicals and Electronics industries. All these industries are benefitted as they contribute at various levels of an automobile assembly line. Given below is a summary of the indirect impact on the aforementioned industries (Fig. 7.10).

The state-EV policies (S3) also show some interesting results. The most prominent result is the negative impact on the manufacturing fuels industry which primarily consists of petrochemicals segment (Table 7.12).

The increase in electric vehicles on the road leads to a decreasing demand for the conventional fuel sources of petrol and diesel resulting in a negative impact. The leather and basic metals and metal goods industry in Bihar show a significant improvement due to the large unorganized

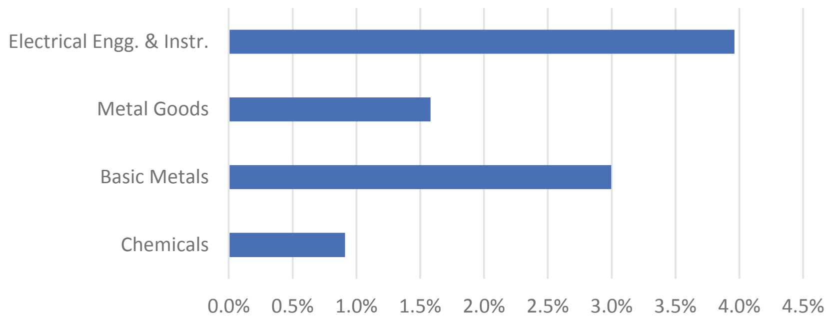

Fig. 7.10 Indirect output impacts (average % differences from baseline between 2020–2030)—Tamil Nadu auto-component manufacturing (*Source* Results from the model)

Table 7.12 Indirect output and employment impacts (average % differences from baseline between 2020–2030)—state EV policies

Sr. no	*Sector*	*State*	*Output (%)*	*Employment (%)*
1	Leather	Andhra Pradesh Bihar Maharashtra	Below 1	Below 1
2	Basic metals	Delhi Andhra Pradesh Uttar Pradesh	5–20	1–6
3	Metal goods	Delhi Bihar Uttar Pradesh	1–11	Below 10
4	Chemicals	Karnataka Uttar Pradesh Maharashtra	Below 5	Below 3
5	Manuf. fuels	Tamil Nadu Karnataka Maharashtra	Below 1	Below 1

Source Results from the model

sector in the state present in the aftermarket segment of the respective sectors.

iii. **Environmental impact**

As a result of various automobile policies, the increase in manufacturing activities across the states will also lead to a rise in CO_2 emissions leading to negative environmental impact in the respective states. The results show that although all policy scenarios lead to increase in CO_2 emissions, the degree of emissions increase varies across the states.

The AMP 2026 policy scenarios of Automobile output (Scenario 1.1) and auto-component output (Scenario 1.2) lead to an increase in the manufacturing of the Original Component manufacturers as well as the auto-component suppliers across the supply chain at various levels and not just from increase in the automobile fleet on the roads. The results show that states in which the larger automobile hubs are present show the highest impact, compared to the rest of the states with lower intensity of automobile manufacturing. Given below are the resulting emissions increase in various states (Fig. 7.11).

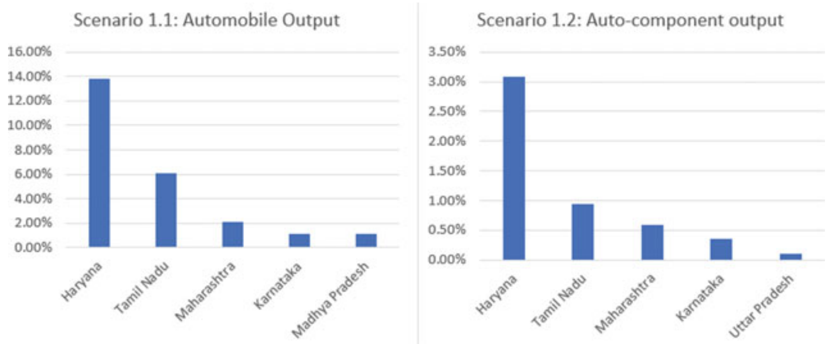

Fig. 7.11 CO_2 emissions (average % differences from baseline between 2020–2030)—automobile—auto-component output (*Source* Results from the model)

Haryana and Tamil Nadu are again top the states in both the scenarios due to the large manufacturing ecosystem present in the states.

As a result of the lockdown imposed and the subsequent decrease in manufacturing activity due to sluggish consumer demand, we see that it leads to a positive impact on the environment at-least in some states (Fig. 7.12).

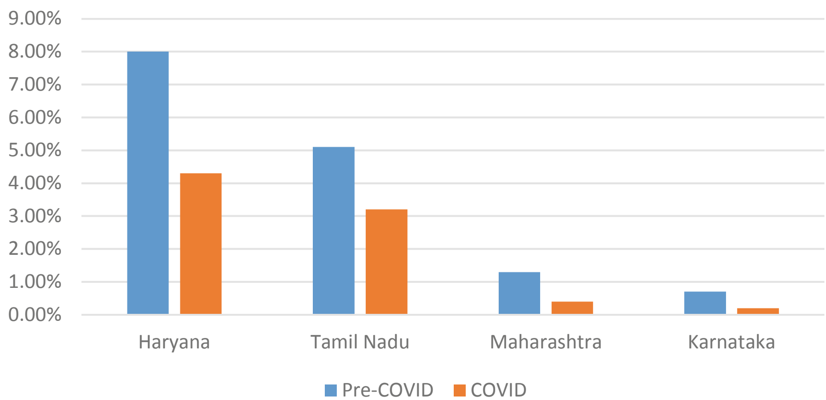

Fig. 7.12 CO_2 emissions (average % differences from baseline between 2020–2026)—COVID-impact: automobile output (*Source* Results from the model)

All the top 4 states shown in Fig. 7.12 show a decrease in CO_2 emissions resulting from COVID-19 and the decrease in manufacturing and other economic activities in the respective state. These states are not only the top automobile manufacturing hubs as shown by the results, but are also host to a number of ancillary industries as shown in Table 7.12 which have experienced increase in sectoral output as well as employment. Thus, these states have been hit hard by the pandemic due to the subsequent lockdowns that were imposed.

The net impact of EV policies on the environment includes the expected decrease in CO_2 emissions due to increase in EV fleet on the road whereas an expected increase in CO_2 emissions is due to increase in electricity usage generated from thermal power plants (Fig. 7.13).

The results show that Andhra Pradesh has the highest increase in CO_2 emissions of 1% and complementary to it, the highest electricity use as well of 9% in the given policy period. Andhra Pradesh is endowed with large coal deposits thus resulting in increase in thermal power generation due to the comparative advantage the state has. The rest of the states show CO_2 emission increase of less than 1%. Bihar is second highest in terms of electricity usage, which could be the result of the state's active policy of promoting and supplying e-rickshaws for local transport at a highly subsidized rate. The developed states of Tamil Nadu, Karnataka and Maharashtra closely follow in terms of electricity usage increase. Delhi

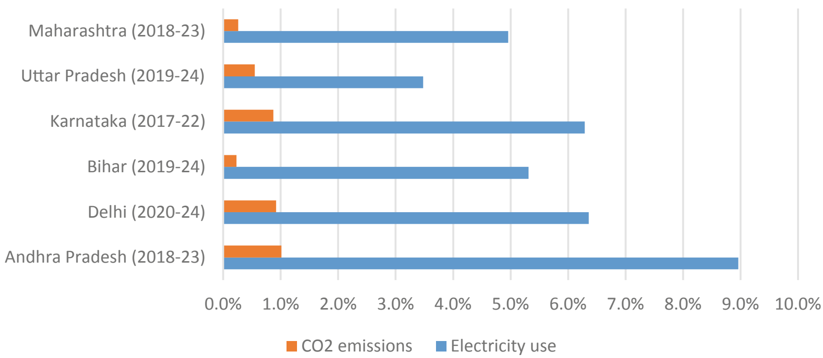

Fig. 7.13 CO_2 emissions (average % differences from baseline between periods given)—state EV policies (*Note* The time period in brackets is the policy period for the respective states. *Source* Results from the model)

Table 7.13 Summary of key performing states in each scenario

Sr. no	*Scenarios*	*Key states*
1	Automotive mission plan 2026 (Scenario 1.1–1.3)	Karnataka, Tamil Nadu, Haryana
	COVID-impact (Scenario 1.4)	Maharashtra, Tamil Nadu, Haryana[a]
2	State electric vehicle policies (Scenario 3)	Karnataka, Maharashtra, Uttar Pradesh

Note [a]For the COVID-scenario the worst affected states are summarized
Source Results from the model

on the other hand is the only state which has shown increase in CO_2 emissions more than the actual electricity usage. In Table 7.12, we see that the most capital intensive as well as CO_2 emitting sectors of Basic Metals and Metal goods industries which constitute industries such as iron and steel, copper, aluminium, zinc and tin (and articles thereof) sees the highest output and employment increase for Delhi. Delhi, due to is high connectivity with industrial and service sector parks in neighbouring regions such as Haryana and Uttar Pradesh (which also has operational EV policy), caters to the economic activities in these regions as well as resulting in increase in industrial activity in the region.

Table 7.13 shows that for AMP 2026, Haryana and Tamil Nadu show positive impact across all the parameters after which Karnataka shows moderate results as well vis-à-vis rest of the states. For the seven state electric vehicle policies we see that Karnataka, Maharashtra and Uttar Pradesh perform well not only in terms of direct impact of electric vehicles on the automobile industry but also in terms of EV component manufacturing as well, especially battery manufacturing (Fig. 7.9; Fuchs et al., 2014). The impact of COVID-19 on the Electric Vehicle segment in India is minimal, as it is at a very nascent stage in its development and its contribution towards the national economy, relative to the conventional internal combustion vehicle segment remains low (NITI Aayog & Rocky Mountain Institute, 2020).

7.8 Conclusion

The automobile industry and its components have been the major constituent of industrial manufacturing in India and the highest growing sector due to increased demand and improved supply chain. However, in the recent years, the sector has faced a slowdown due to various structural and policy level changes. This study analyses the impact of the automobile and autocomponent industry policies undertaken at the National and state level. The analysis reveals that the automobile industry is largely dependent on imports for its supply chain. Even though most of the states are major exporters of auto-components, the automobile manufacturing hubs in India should adopt further localization strategies in order to reduce the trade deficit. The states of Haryana and Tamil Nadu have been the largest beneficiaries of Automotive Mission Plan 2026 due to the well-established and globally integrated automotive manufacturing hubs. However, the indirect impact has given a positive impetus to Madhya Pradesh, Jharkhand, Uttar Pradesh and Gujarat which have benefitted from the development of ancillary industries. These states have seen an increase in output as well as a positive impact on other macroeconomic variables as a result of which overall economic development is observed at the sub-national level. The development of the automobile components sector and expansion of supply chains to the other states would facilitate the reduction in import dependency in the future through innovative policies and attractive investment opportunities. The growing domestic market would require well linked regional supply chains across the states.

The results for seven state-EV policies reveal that Karnataka and Maharashtra show promising results as these two states were the first in the country to inculcate an ecosystem where EVs are promoted at a decentralized sub-national level and not completely executed by the central government. However, the positive impact of state-EV policies is not translated into promotion of other components of EVs such as battery production. With rise in EVs, the demand for EV batteries, the most important component in terms of value addition, will also increase. Only Maharashtra and Uttar Pradesh show a strong increase in battery manufacturing as a result of their state-EV policies. If other states do not increase their capacity for battery manufacturing, then without cost-effective strategies it would not be possible for their EV companies to compete with the conventional Motor Vehicle market. The government must focus on developing the domestic component market or else the dependence on imports may increase in future. At the same time, the market demand can only be created for EV when the availability of EV vehicles is made at affordable rates. This would require investment in the recharging infrastructure or else limited demand may never translate itself into supply led economies of scale. The government should put special focus on research and development of latest technologies in the EV components. For the EV policies, the net CO_2 emissions are actually increasing in all states, though marginally. This is counteractive to the intention of promotion of EVs as increase in CO_2 emissions is resulting from dependence on thermal energy sources for electricity generation. Thus, an additional impetus should be provided for promotion of renewable energy sources in the power sector for supporting EV charging infrastructure across the country. In the endeavour of achieving 30% electric mobility in the transport sector, India is expected to cut its fuel import bill by as much as USD 60 billion by 2030 (Lohani, 2020). Thus, EVs can assist India's clean energy transition and as a consequence contribute to India's Nationally Determined Commitments (NDCs) of cutting emission intensity by 33–35% and attaining Sustainable Development Goal (SDG) 13, of taking urgent action to combat climate change and its impacts.

Finally, the COVID-19 pandemic has negatively impacted all the automobile hubs across the country. As a result of the industry's high contribution to Indian economy along with being one of the largest employers, almost all the socio-economic sectors have directly or indirectly been affected. The automobile policies have supported multiple supply-side incentives to make India a manufacturing hub in order to compete at equal-footing with China in the global market. However, such prolonged negative impact of the pandemic now has resulting in a pessimistic sentiment leading to sluggish demand in the market. Since the Indian automobile industry is considered as an important indicator of the economic health of the country, the government should provide various demand-side incentives for reviving the industry and instilling confidence amongst automobile (as well as auto-component) manufacturers which will have a positive impact on the entire economy, both directly and indirectly.

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CHAPTER 8

Regional Impacts of National Energy Policies in India: An E3-India Application

Surabhi Joshi and Kakali Mukhopadhyay

8.1 Introduction

Regional dynamics of national-level energy policies is complex and difficult to analyze. Driven by India's commitment to existing Nationally Determined Commitments (NDCs) (UNFCCC, 2015) ratified under Paris Agreement 2015, Indian energy sector is transitioning. NDCs target addition of 175 GW renewable capacity by the year 2022 and of 450 GW by 2030 (CEA, 2019b). Concomitantly, the focus is also to

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reduce the carbon intensity of GDP by 33–35% from 2005 level through sector-specific energy efficiency initiatives.

The transition trajectory will also be influenced by the proposed structural changes within the power sector. For instance, the proposed Electricity Amendments Act 2020 mandates rationalization of prevailing cross subsidy with provisions for direct benefit transfers for electricity subsidy disbursement. Prevailing economic uncertainty emanated by the COVID-19 pandemic adds another layer of complexity to the ongoing energy transition trajectory. All these interventions are expected to have unprecedented distributive impacts across different regions of the economy.

The structure and growth of power sector has been primarily defined by the unique energy resource endowments, unequal economic clouts and diverse political aspirations of Indian states (Dubash et al. 2018). Power generation in India is predominantly coal-based with thermal generation accounting for 86% of the generation mix in 2019 (CEA, 2019a). Traditionally, energy geography for coal generation is skewed with coal production concentrated primarily in less developed eastern and central Indian states like Jharkhand, Chhattisgarh and Madhya Pradesh and generation capacities and consumption centers concentrated in larger economically affluent western and southern states like Maharashtra and Gujarat.

India also has over 1097.4 Giga Watt (GW) of renewable generation potential which is highly underutilized with standing generation capacity of only 89.23 GW (CSO, 2019; CEA, 2020). Advent of deflationary renewables (Henbest, 2020) is redefining this dynamics, with ambitious renewable capacity targets already in place. The new capacity addition is driven not only by the existing energy geographies but also by emerging structural, institutional and techno-economic linkages for renewable energy in various states. For instance, larger and economically affluent Western and Southern states of India i.e. Gujarat, Rajasthan, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh also have the best sites for solar and wind-based generation potential. Moreover, these states have been early movers in renewable space, bringing in successful policies for both capacity addition and manufacturing of renewable generation technologies (Sharma & Sinha, 2019). Image 8.1 provides a broad overview of the existing energy-economy geography and status of RE potential utilization across key states.

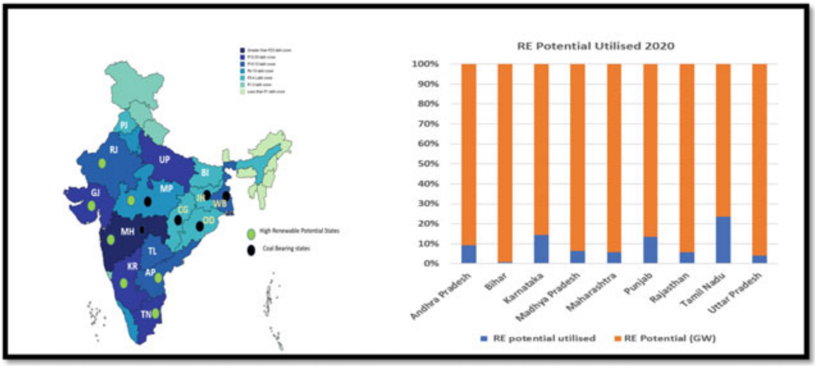

Image 8.1 Energy-economy geography and renewable trajectory across states (*Source* Adapted from Sondhi [2019] and modified by the authors)

Along with the given energy-economy geography, ongoing structural changes in the economy will directly inform the energy mix and demand growth in a region (Schafer, 2005). A shift to cleaner energy augmented by efficiency measures under NDC's are expected to bring in greater energy security, efficient resource management and high decarbonization potential. The potential and preparedness for energy efficiency varies across Indian states.

A recent report by Bureau of Energy Efficiency (Government of India) reveals a high state level potential to realize energy savings from energy efficiency in India (Kumar et. al., 2018). The study identifies states of Haryana, Karnataka, Kerala as achievers where a series of policy instruments have been implemented for enhancing energy efficiency program. The study primarily maps the preparedness to efficiency implementation across states but the efficiency programs also have macroeconomic benefits which have not been studied in detail cross regionally for India (Alexandri et al., 2016; IEA, 2019).

Further, retail tariff design can also have wide impacts on energy transition trajectory (Ansarin et. al., 2020). Constitutionally power sector in India is in the concurrent list and is jointly administered by both central and state governments. At the national level, the Ministry of Power and Ministry of New & Renewable Energy make policies, however, individual states have autonomy to create their own energy policies. Electricity being a concurrent subject, power tariff is primarily determined at state regulatory commissions. Use of cross subsidies is highly prevalent across states where Commercial and Industrial (C&I) consumers subsidize electricity for agricultural and domestic consumers. Moreover, other exemptions and duties are also levied by the state government according to the developmental goals and aspirations of the individual state.

In the financial year 2018–2019 the Indian utilities booked a total subsidy of USD 15,770 million (PFC, 2020). Approximately 16.5% was adjusted through the cross-subsidized tariff and rest was adjusted with state-allocated power sector subsidy budget. Often state governments default at paying the full balance of the subsidy disbursed which accumulates as regulatory assets[1] for distribution companies, or Discoms. This creates a major hurdle in new energy infrastructure development. The accumulated deficits lower the borrowing power for distribution companies making it difficult for them to borrow for capital investments and projected expansions. The total accumulated regulatory assets for the Discoms as on March 31, 2019 is over USD 7,185 million in India. The states allocated between USD 1085–1700 million—as power sector subsidies, 90% of which was for agricultural consumers. The state of Punjab and Maharashtra reveal the least gap in average revenue recovery (ARR) by Discoms, whereas the highest gap is seen for southern states of Tamil Nadu and Andhra Pradesh. Table 8.1 details total energy sold, gap in revenue recovery and total subsidy facilitated by state governments in 2018–2019.

The precarious financial position of Discoms is also accentuated by a growing trend to opt for open access by high paying Industrial and Commercial consumers primarily for the cheaper power available by renewable energy Independent Power Producers (IPPs) (PFC, 2020). The existing tariff structure and market rigidities are thus posing severe threats to the financial health of power sector with escalating debt and large accumulation of non-performing assets. This is constraining financial space for states to invest in progressive renewable policies.

E3-India is a powerful analytical tool that uses dynamic complex systems framework to provide insights on energy-economy-environment interaction at regional level. In this chapter, we first evaluate energy-economy interactions associated with the existing renewable energy and energy efficiency targets under nationally determined commitments. This

[1] Regulatory assets include previously-incurred losses that are in the nature of deferred expenditure and that can be recovered from consumers in future provided allowed by regulatory authorities.

Table 8.1 State-wise distribution sector profile and subsidy for power sector (2018–2019)

State	*Gross energy Sold (MU)*	*Gap in ARR (INR/kWh)*	*Total Subsidy (Million USD)*	[a]*Total Subsidy for agriculture (Million USD)*
Punjab	47,446	−0.07	123.4	111.0
Tamil Nadu	76,126	1.52	109.9	98.9
Andhra Pradesh	49,992	2.67	86.5	77.8
Bihar	18,142	0.39	54.9	49.4
Karnataka	52,857	0.24	169.8	152.8
Madhya Pradesh	48,031	1.3	165.9	149.3
Maharashtra	103,166	−0.19	147.8	133.0
Rajasthan	57,294	0.06	154.5	139.0
Uttar Pradesh	88,136	0.56	143.9	129.5
National	957,50957509	0.52	1577	1419.3

Note[a] Estimated as 90% of total state subsidy to the power sector
Source PFC (2020) and Authors' calculations

is followed by progressively modelling the propositions for rationalization of cross subsidies along with disbursement of electricity subsidy by direct benefit transfers as put forth by Government of India under amendments to electricity act 2020. We further include the impacts of existing COVID crises on energy-economy trajectory. Finally, the overall emergent impacts of all these interventions on a state economy are captured using an integrated scenario.

This analysis is performed for nine key states of India representing a mix of diverse energy geographies and distinct economic reality. The choice of the states has been made to achieve maximum diversity with respect to energy mix, economic status and existing political clouts in the states. Table 8.2 details some key parameters for the states under study including energy mix, per capita availability of electricity and rate of rural electrification.

The selection can be regionally classified as:

1. Southern states including Andhra Pradesh-Telangana, Karnataka and Tamil Nadu which are economically progressive reflected by per

Table 8.2 State-wise power sector profile

	Coal	*Total Thermal*	*Nuclear*	*Hydro*	*Solar*	*Wind*	*Total RES*	*Per Capita electricity consumption (kWh)*	*Power supply to rural areas Hr/day*
Andhra Pradesh & Telangana*	19.06	24.33	0.28	4.15	3.63	4.09	12.64	1688	23.63
Bihar	5.34	5.34	0.00	0.11	0.15	NA	0.35	311	21.83
Karnataka	9.85	10.31	0.70	3.59	7.3	4.79	15.26	1396	18.93
Madhya Pradesh	16.06	16.39	0.27	3.22	2.33	2.52	5.07	1084	23.47
Maharashtra	26.34	29.85	0.69	3.33	1.87	5	9.85	1424	24
Punjab	8.33	8.74	0.20	3.91	0.95	NA	1.60	2046	24
Rajasthan	10.86	1.33	0.55	1.94	5.35	4.3	9.79	1282	22
Tamil Nadu	11.83	14.51	1.45	2.18	4.22	9.38	14.75	1866	24
Uttar Pradesh	18.69	19.24	0.29	3.40	1.18	NA	3.35	606	17.58

Note [a]State of Telangana is modelled along with Andhra Pradesh in E3-India as the state was part of Andhra Pradesh till 2014 and there was no separate date series available for separate treatment of the state
Source PIB (2019) and MNRE (2020)

capita electricity availability of 1396–1866 kWh which is significantly higher than national average of 1181 kWh. These states are also characterized by comparatively high renewable endowment and also existing generation capacities. At present, Tamil Nadu has the highest installed wind capacity and Karnataka has highest installed solar capacity in the country.

2. Western and Central states of Maharashtra and Madhya Pradesh provide a binary of economically advanced and developing, but renewable rich states respectively. The state of Maharashtra has the distinction of being the largest state economy, and also home to highest thermal capacity in the country. The state also serves as the largest peak demand load making it a net importer of electricity whereas the state of Madhya Pradesh has moderate electricity demand but high generation capacity making it a net exporter of electricity.
3. North-Western states of Punjab and Rajasthan find the contrast in being the states with shared boundaries but contrasting renewable endowments geographically. The total renewable generation potential in Rajasthan is estimated to be 162.2 GW with Punjab having a potential of just 6.25 GW (CEA, 2020). However, the state of Punjab is distinguished to have about 98% area under irrigation much higher than Rajasthan (~42%) along with relatively higher penetration of electricity in the energy mix historically.
4. Northern states of Uttar Pradesh and Bihar are characterized by having one of the lowest per capita electricity consumptions of 606 kWh and 311 kWh respectively along with inadequate power supply in the rural areas. Both the states also have relatively low renewable potential and still lower installed capacity. The contribution of agriculture in GDP is high for these states along with rampant use of diesel generators for irrigation. The states also have relatively higher tariffs for agricultural consumers but are primarily agrarian economies with underdeveloped energy infrastructure specifically in rural areas.

These states in aggregate cover 66% of population, 62% GDP and 62% of total energy use for India.

The regional segregation is not enough to fully understand the diversity in energy profile and dynamics of change for current energy transition trajectory so we aim at assesing impacts at the state level. Policies for both renewable scale-up and efficiency improvement provide a strong economic imperative toward green growth (Ferroukhi, et al., 2016; Kumar, 2017). Further, these policies are also expected to bring faster economic recovery for India in the existing COVID situation (Politt, 2020). The existing power sector tariff structure has been responsible for sub-optimal recovery posing immense financial pressure with mounting debt on the power sector. However, as a developmental policy, it has been instrumental in keeping electricity affordable for agricultural consumers but costly for industrial and commercial consumers. As most of the energy sector policies are implemented at state level, an understanding of regional impacts associated with the green growth and subsidy rationalization policies is also essential to design an effective COVID recovery plan at regional level.

The next five sections look into understanding impacts of 4 key policy interventions on energy-economy linkages across the nine states. The scenarios have been designed as progressive mixed shocks to understand the dynamics of change along with a closer to real-life integrated scenario where all the policies are simultaneously implemented to understand the overall and emergent impacts. Table 8.3 details the scenarios studied. The next section (Sect. 8.2) deals with the impacts of renewable capacity scale-up to aggregated national capacity of 450 GW by 2030. This is followed by an analysis to understand the impacts of energy efficiency policies in Sect. 8.3. In this section key energy-intensive sectors of state economies undertake efficiency measures to reduce energy intensity of

Table 8.3 Summary of energy policy scenarios

Sr. no	*Scenarios*	*Type*
1	Baseline Scenario	Business As Usual Scenario
2	Renewable Scenario	Progressive (National Level)
3	Renewable + Efficiency Scenario	Progressive (National Level)
4	Renewable + Efficiency + Moderate Subsidy Phaseout	Progressive (state specific)
5	Renewable + Efficiency + Subsidy rationalisation	Progressive (state specific)
6	Renewable + Efficiency + Subsidy rationalisation + COVID impacts	Progressive (national Level)
7	Renewable + Efficiency + Subsidy rationalisation + COVID impacts	Integrated assessment

Indian GDP by 33–35% of 2005 levels. Section 8.4 and 8.5 takes a look at macro economic impacts of structural change in existing power sector by mapping impacts of power sector subsidy rationalization to meet the National Tariff Policy 2018 recommendations along with compensatory direct benefit transfer. This is followed by Sect. 8.6 which evaluates impacts of energy transition trajectory under the demand-supply shock situation due to the prevailing COVID situation. In reality all these policies and discernible changes will not only co-habitat but will also mutually impact each other defining the developmental trajectory of a region. In Sect. 8.7 we study combined impacts of all these interventions by creating integrated scenario which is followed by key conclusions in Sect. 8.8.

8.2 Impacts of National Renewable Energy Capacity Scale-Up to 450 GW by 2030 on Regional Economies

India's ratification to Paris Agreement in 2015 has been the key driver for setting an ambitious--renewable energy target of adding 175 GW of renewables by 2022 including 100 GW of solar and 60 GW of wind-based installations. This target was doubled to 450 GW of non-fossil fuel-based energy capacity addition by 2030, as committed by the Indian Prime Minister in the 2019, UN summit (*The Hindu Business Line*, 2019).

As per June 2020, the total utility scale solar and wind capacity in India stands at 69.8 GW including 32.56 GW of utility scale solar and 37.24 GW onshore wind installations. Further, there is over 52.35 GW of capacities in pipeline either tendered or auctions proposed (Bridge to India, 2020a). As detailed in Image 8.1, existing renewable energy (RE) potential for most of the states is highly underutilized. The state of Tamil Nadu is at the forefront in terms of renewable capacity addition, meeting 26.9% of its potential (including pipeline projects) whereas states like Maharashtra and Rajasthan with highest RE potential among states have comparatively a slower trajectory of RE capacity addition.

8.2.1 Inputs Design for the Scenario

E3-India provides various options of renewable trajectory design to meet the requisite targets at state level for 24 power sector technologies using the Future Technology Transition module. In order to have more accurate simulation of capacity at state level, we align the capacity scale-up for baseline and high renewable energy pathways to the baseline and high renewable energy pathways projected in recently released TERI-ETC report, *Renewable power pathways: Modelling the integration of wind and solar in India by 2030* (Spencer et al., 2020). The ETC's Baseline Capacities Scenario (BCS) is aligned with the existing assumptions National Electricity Plan 2018. The High Renewable Energy Scenario (HRES) has a higher installed capacity of 450 GW by 2030 which is aligned with assumptions of the CEA's Optimal Mix study (CEA, 2019b).

The grid capacity estimation for ETC analysis has been performed using a production cost model PyPSA India (TERI, 2020) which provides a 15-min time block data for one year (from April 1, 2030 to March 31, 2031) including plant-level data for coal-based generation. Generation forecasts for 1860 time periods for 22 key states and one integrated north-eastern region are available for download. We aggregated the available generation data state-wise and by generation technology to obtain the annual generation figures for state-level coal, solar and wind in 2030. Technology-specific capacity utilization factors were then used to obtain state-wise breakup of capacity addition for coal, wind and solar till 2030.

The national-level capacity breakup for coal, solar and wind in 2030 are detailed in Table 8.4.

The calibration in E3-India was performed using the bottom-up power sector Future technology Transition (FTT) module by adjusting capacity numbers for solar and wind along with PLF's for coal plants iteratively to reach the requisite optimal mix. As an integrated model the electricity demand from the economy module is matched by the least cost

Table 8.4 E3-India model calibration (modified): National level

Sr. no		*Capacity by 2019 GW*			*Capacity by 2030 GW*		
		Thermal	*Wind*	*Solar*	*Thermal*	*Wind*	*Solar*
1	ETC Baseline	231	38	35	263	130	189
2	Base Line E3-India	231	38	35	260	129	188
3	ETC High RE	231	38	35	263	169	229
4	E3-India High RE	231	38	35	260	171	222

Source Spencer et al. (2020), Author's caliberation

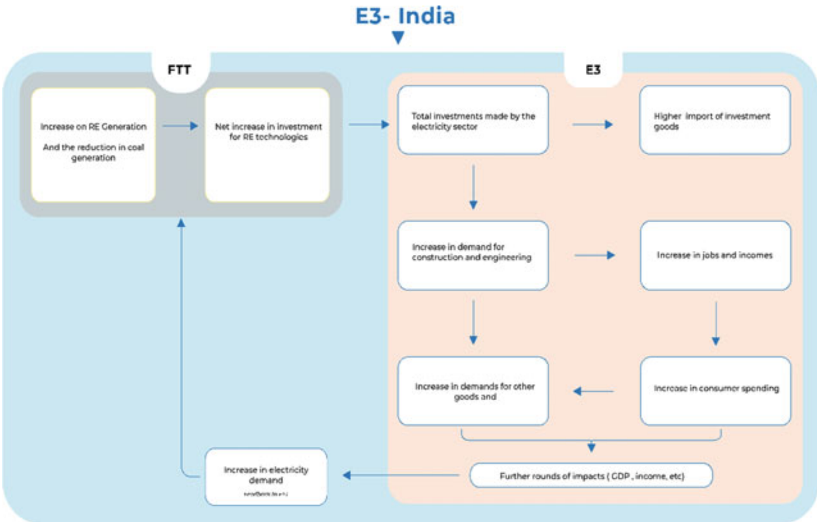

Image 8.2 Increase in investment for RE technologies across states (*Source* Author's delineation)

supply from the FTT module through pairwise comparison of LCOE of generation technologies and learning curves. The adjustment of capacity numbers is endogenously done in the model leading to a marginal difference between ETC and our scenario.

The impacts of renewable capacity addition on the overall economy are estimated by two routes–-first by assessing the effects of incremental investment in the renewable energy sector and second by assessing the impact of the reduction in the cost of electricity (Image 8.2–8.3).

The investments in RE will lead to an increase in the direct and indirect demand associated with the sectors like construction and engineering, along with concomitant change in employment and income. This investment impact thus flows into the economy as change in consumer spending and demand for consumer goods.

This positive economic effect leads to further increase in energy demand. E3-India is a demand driven model where supply matches demand with a commensurate increase in generation capacity in a recursive loop. Further, impacts of reduction in cost of electricity generation also flow through the economy loop as illustrated in Image 8.2.

The impacts of reduction in cost of electricity generation also flows through the economy loop leading to decrease in the input price of electricity for all other sectors of the economy. Decrease in the cost of electricity generation flows in as reduction in the price of electricity across consumers and industries leading to increase in electricity consumption and other goods along with favorable impacts on household incomes (Image 8.3).

Fig. 8.1 and Table 8.5 details the state-wise break up for existing and increased renewables capacities for the baseline and high RE scenario along with increased renewable in generation mix by 2030. The high RE potential states of Rajasthan, Andhra Pradesh &Telangana, Karnataka, Tamil Nadu and Maharashtra add over 30 GW additional solar and wind capacity by 2030 whereas low renewable potential states of Punjab, Bihar and Uttar Pradesh add 2–10 GW of primarily solar-based capacity.

The impacts of new solar and wind-based capacity addition on generation costs is deflationary (Bridge to India, 2020b) The increased capacity of deflationary wind and solar in the energy mix results in reduced cost

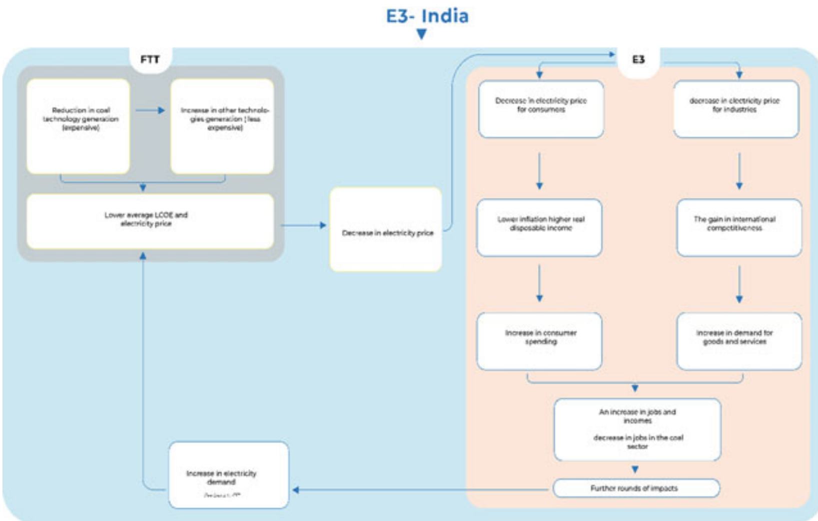

Image 8.3 Deflationary impacts of Solar and Wind addition in energy mix (*Source* Author's delineation)

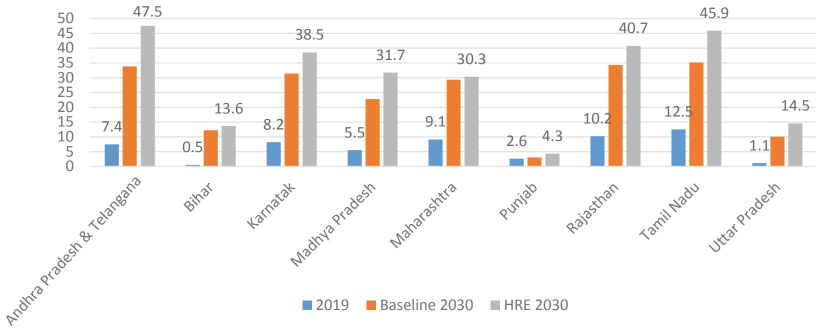

Fig. 8.1 Installed renewable capacity by 2030 (*Source* Results from the model)

Table 8.5 Percentage of renewable energy in generation mix 2030—High RE scenario

State	*2019*	*HRE 2030*
Andhra Pradesh & Telangana	11.2	49.8
Bihar	6.3	85.8
Karnataka	18.6	51.3
Madhya Pradesh	15	57.1
Maharashtra	10	18.7
Punjab	4.3	7.77
Rajasthan	19.5	50.9
Tamil Nadu	24.3	52.7
Uttar Pradesh	1.6	13.4

Source Results from the model.

of electricity production and concomitant increase in demand as per price demand elasticity of electricity prevailing in specific state.

The consumption of electricity across states increase by 0.24–2.3% with reduction in cost of electricity by 0.48–4.7% as illustrated in Fig. 8.2. The state of Bihar shows maximum change in both price and demand as renewable energy capacity for Bihar increase to 13 GW by 2030 from the existing ~500 MW with deflationary solar accounting for close to 80% of the state generation mix. Contrastingly in the state of Maharashtra with high RE potential, the capacity scales up to over 20 GW but total renewables (solar + wind) in state generation mix only accounts for 17–18% of the total generation, indicating a suboptimal trajectory in terms of renewable penetration in the energy mix. Most of the other states reach over

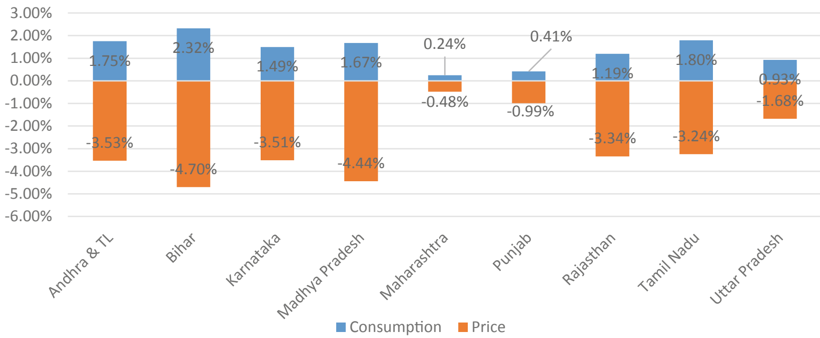

Fig. 8.2 Percentage change in electricity price and consumption due to RE scale up (*Source* Results from the model)

50% renewables in the generation mix. The state of Punjab which has comparatively low RE potential and high demand for electricity reaches only 7–8% of renewable penetration. However, with the proposed electricity wholesale market in place, the states will have the ability to import cheap renewables from the grid to reduce its power purchase cost and integrate higher renewables in its power portfolio (Patel, 2019; Joshi et al., 2021).

The incremental renewable capacity addition also leads to increased investment in energy infrastructure and concomitant increase in demand. The reduction in cost of electricity production will also have positive spillover effects on increased output and employment.

We find GDP and employment increase although not commensurately across all states. In case of a coal-bearing state like Madhya Pradesh, GDP increases by 0.34% but employment goes up marginally as the coal mining-based employment reduces by 13% with reduction in coal-based power generation in the state. In case of Punjab although the net increase in renewable capacity is low, its comparatively higher with respect to the baseline projections. As new investments in capacity addition are inclusive of increased investment in transmission and distribution infrastructure, the energy sector employment marginally goes up between 0.01–0.29% for the states. The indirect cross-sectoral employment impacts are also positive for electronics and hotels and catering services.

Thus, increasing RE capacity for states lead to positive energy-economy trajectory where consumption of electricity increases as the cost of generation decreases, GDP and employment increases for all the states but distributive impacts across the sectors vary with contraction in the coal sector in Madhya Pradesh and Maharashtra. Further the regional carbon emissions reduce across all states by 2030. The highest carbon emission reduction of 16.5% is observed by Madhya Pradesh with only marginal reduction of 0.25% for the state of Maharashtra. Following the assessment of impacts for high RE trajectory we now evaluate impacts of energy efficiency interventions on the states.

8.3 Reducing Energy Intensity of Key Sectors Toward Meeting the NDC Targets

Under existing Nationally Determined Commitments, India is expected to reduce carbon emissions intensity of GDP by 33–35% from the 2005 levels. Government of India's Bureau of Energy Efficiency (BEE) has initiated several energy efficiency initiatives for reduction of industry-linked emissions and has also introduced standards and labeling, commercial and residential buildings codes. Diverse initiatives for demand-side energy efficiency management in agriculture and municipalities are also in place. An ambitious energy efficiency scheme i.e. Perform Achieve and Trade (PAT) for industries and other energy-intensive sector was launched in year 2015. PAT led to avoided emissions of 31 $MtCO_2$ and a total of targeted energy savings of 19 Mtoe. Further, UJALA scheme for distribution of energy-efficient LED tube lights resulted in estimated energy savings of 294.45 million kWh per year with an avoided peak demand of 135 MW and greenhouse gas emissions reduction of 0.2 $MtCO_2$ per year (Bakre et al., 2018).

Specific state-level interventions for increasing efficiency of power sector from both supply and demand side are also in place e.g. Ujjwal Discom Assurance Yojana (UDAY) and Demand Side Management (DSM) regulations. The Government of India's UDAY scheme, launched in 2015, was aimed at financial turnaround of Discoms, and facilitates minimization of transmission and distribution losses through consolidating infrastructure and monitoring system (Rawal et al., 2014). Moreover, state-level mandate for demand-side management (DSM) regulations by state regulatory commission are in place for many states.

The inputs for reduction in energy intensity by 2030 was modeled as sector-specific energy efficiency targets as detailed in Table 8.6. The scenario creation involved augmenting high renewable scenario with sectoral energy efficiency targets of selected PAT identified industrial sectors and household efficiency investment estimates available in Bureau of energy efficiency available in energy efficiency potential in India report (Mathur et al., 2018). It is assumed that industrial sectors invest for energy efficiencies incrementally but in case of households, the investment in efficiency is funded under government expenditure.

The key output variables studied are total reduction in energy intensity across states, the total change in state GDP and employment due to efficiency-linked investments or reduction in investments across the sectors.

In addition to renewable energy and energy efficiency trajectories which are aligned to NDC targets we in the following section model the impacts of proposed regulatory change in terms of cross-subsidy rationalization in the power sector as mandated by recently proposed draft Electricity Amendment Bill 2020 (CERC, 2003).

The energy savings are entered into the model as exogenous reductions in fuel consumption (FRGH, FREH, etc.) along with exogenous investment in key sectors associated with energy efficiency activities like electrical equipment. The cost of the investment is recoupled with higher prices in the investing sector, or through higher tax rates if the investment is publicly funded. Scenarios that assess energy efficiency therefore

Table 8.6 Sector specific energy efficiency targets for 2030

Sector	*% reduction in energy use*	*Investment (million USD/Th Toe)*
Agriculture (E)	16	0.18
Residential (E)*	15	0.09
Services (E)	30	0.17
Iron & Steel (E)	18	0.08
Cement & Bricks(E)	7	0.46
Paper & Pulp (E)	18	0.66
MSES (Textile) (E)	2	0.52
0.Thermal (C)	17	0.70

Source Authors' calculations

typically show gains in investment and output of the sectors that supply investment goods. The sectors that supply energy lose out. Investment in household energy efficiency allows a shift in consumer spending patterns. In some states, there is a reduction in fossil fuel imports, which leads to a modest increase in GDP. Image 8.4 summarizes the main economic interactions mapped in the analysis.

The efficiency scenario is progressively added on the high renewable energy scenario for analysis. This was done to understand the impacts of increased energy efficiency under high renewable trajectory as articulated under existing nationally determined commitments.

The impact of efficiency scenario was studied in terms of change in state energy intensity, GDP and regional employment.

The existing economic structure, energy consumption mix and energy efficiency measures exert significant impact on energy intensity of a region. The capability of a state to reduce its energy intensity therefore depends on the existing energy mix, developmental stage of a region and the complexity of its economic structure. Our results as illustrated in Fig. 8.3, reveal that fuel energy intensity reduction potential with respect to the 2005 baseline varies across states (24.9–55.5%). The state of Punjab shows a relatively lower reduction in energy intensity (24.9%) as compared

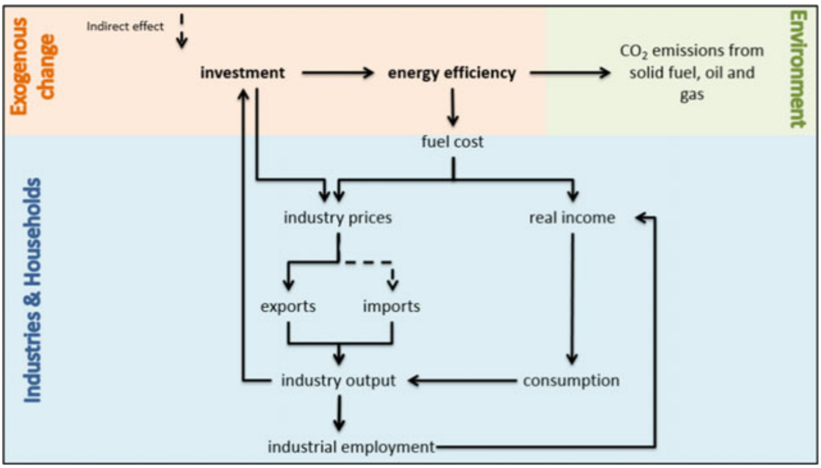

Image 8.4 Main economic interactions of energy efficiency (*Source* Authors' Delineation)

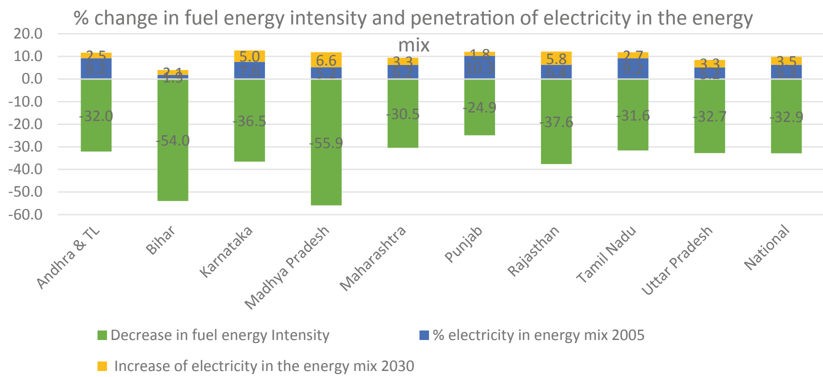

Fig. 8.3 Percentage change in fuel energy intensity and penetration of electricity in energy mix 2030 (*Source* Results from the model)

to the national average, whereas states like Bihar and Madhya Pradesh will be able to reduce their energy intensity by 53-55% from the baseline. The cross-sectoral review reveals that for the states of Bihar and Madhya Pradesh, the fuel demand of power sector goes down by 20–60% due to incremental RE in the energy mix.[2] Further, demand pattern across the sectors also change with greater energy consumption for domestic consumers and non-metallic minerals manufacturing (cement) in 2030.

A positive shift in energy mix is visible both at national and state levels where the overall electricity penetration in energy mix increases by 17.5–126% by 2030. The state of Punjab has comparatively smaller reduction in fuel energy intensity due to lower endogenous renewable generation potential. However rate of penetration of electricity in the state was already 10.1% in the year 2005 (one of the highest among states under study) and goes up to 12.1% in 2030.

The efficiency scenario also models investment in the economy with respect to efficiency improvements. The demand for efficiency increases cross-sectoral demands for new electrical and electronics appliances along with introduction of new better technologies driving investments. We find that cross-sectorally energy efficiency increases sectoral employment in power sector, other mining and services sectors specifically in hotel

[2] The fuel use for solar and wind-based generation is modelled to be zero in E3-India.

and catering and other business services for all states. Further the sectoral output for electrical equipment sector goes up for all states. States of Maharashtra, Andhra Pradesh, Madhya Pradesh and Punjab show an increase between 2 and 10.5%. States of Punjab, Maharashtra, Andhra Pradesh and Rajasthan show an increase in agricultural output by 2.5–5.5%. The increase in sector-specific outputs are mainly due to efficiency investments which leads to increase in overall GDP and employment for the states. We estimate the GDP and employment impacts of these efficiency investments for the states (Fig. 8.4).

The GDP impacts of efficiency scenario is much more pronounced than the only RE scenario with an increase in overall GDP by 0.67–2.63%. The states of Rajasthan, Punjab and Maharashtra reveal maximum increase GDP. In the state of Punjab, although the RE generation potential is limited but investment in efficiency leads to increase in output for agriculture sector, which has strong mutlipliers effects in terms of increasing output and employment in construction food and drinks, hotel and catering services thus leading to a positive spillover effect. In case of Rajasthan and Maharshtra the increase in GDP and employment can be attributed to increased investment in the renewable capacity installation along with increased output in agriculture, construction, trade and logistics and electricity supply.

The potential for energy intensity reduction varies across states and is directly linked to existing economic structure and energy mix of the respective state economies. The increase in energy efficiency lowers the

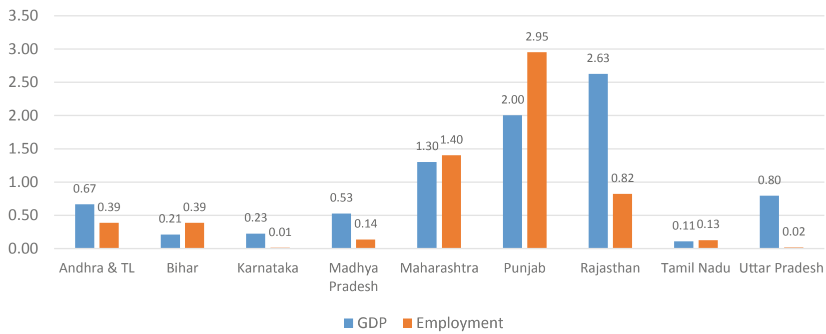

Fig. 8.4 Percentage change in GDP and employment impacts of energy efficiency improvement under High RE scenario (*Source* Results from the model)

energy demand and increases the investment in efficiency technologies in the economy. Regional carbon emission reduces for states of Madhya Pradesh, Punjab, Rajasthan and Karnataka. However additional investments also lead to an increase in regional carbon emissions for states of Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra and Andhra Pradesh from the estimated baseline scenario, however all the states show a significant reduction in energy intensity as compared to 2005 values. Further, renewable scale-up reduces the cost of electricity generation. These policy outcomes not only lead to positive economic impacts but can lead to alternative possibilities for provisioning wider electricity access. Further, these positive trends in energy trajectory provide more options for restructuring existing power sector subsidies in India. The following section estimates impacts of electricity subsidy rationalization across states under high renewable efficiency scenario.

8.4 Rationalizing Cross-Subsidies in Tariff Design

Power tariffs in India are designed to ease access to affordable electricity for a large base of domestic and agricultural consumers by application of cross-subsidies. The prevalence of subsidies has not only led to high accumulated debts for the state utilities/Discoms but has also aggravated the deficit and subsidy burden on the respective state government.

The benefits of subsidy rationalization (partial or complete phaseout of cross-subsidies in power sector) have been reiterated time and again pointing to the benefits of increasing competitiveness of Indian industries by lowering tariffs for commercial and industrial consumers and reduction in revenue gap for state distribution companies. The systematic phaseout of subsidies has been on the list since the Electricity Act, 2003. The recent National Tariff Policy, Ministry of Power (2018), specifies that state electricity regulatory commissions should lay a roadmap to align tariffs within ± 20% of the average cost of supply. Further, the draft Electricity Amendment Bill 2020 proposes direct benefit transfers to agricultural and domestic consumers and with phase-out of cross subsidies in targeted manner.

The amendments for tariff redesign pushed in at national level will have different dynamics at the state level as phasing out of power subsidies for agricultural consumers is a politically sensitive issue. Experience shows that farmers are reluctant to relinquish access to subsidized power even to an option of supply quality improvements. In the year 2019, agricultural consumers were served 25% of total electricity sold by Discoms but paid 3.2% of the revenue contribution. The unit served to revenue generated is the direct outcome of policies and reforms in a specific state. Table 8.7 provides the ratio of percent revenue earned to units sold across consumer categories.

The cost of electricity plays an important role in determining price demand elasticity and factor cost of goods and services. In the E3-India framework, the cost of electricity generation is determined through the FTT module, where the pairwise comparison of generation technology cost function and technology diffusion rate leads to solution for levelized cost of electricity (LCOE). The average LCOE of generation mix is then fed to economy module to determine price of electricity consumption. An exogenous split by providing a prevailing cross-subsidy matrix is applied at state level. Further, the price demand elasticity of electricity use is determined through the time series econometric equations for sector-specific electricity prices in each state.

We study the impacts of cross-subsidy rationalization through two interventions: (1) Subsidy rationalization for all the consumer categories; and (2) Direct benefit transfer to agricultural and domestic consumers. The subsidy rationalization scenarios were applied from the year 2024, to alleviate intermixing with the later described COVID scenario.

Table 8.7 Ratio of category wise revenue realized to units served in 2019

	% unit domestic	*% unit commercial*	*% unit agriculture*	*% unit industrial*	*% unit others*
Punjab	0.75	1.33	0.00	0.98	1.04
Tamil Nadu	0.45	1.53	0.00	1.32	1.14
Andhra Pradesh	0.63	1.80	0.14	1.16	2.05
Bihar	0.53	1.21	0.72	1.21	0.88
Karnataka	0.83	1.50	0.01	1.29	0.93
Madhya Pradesh	0.93	2.43	0.12	1.38	0.88
Maharashtra	1.09	1.98	0.08	1.24	0.85
Rajasthan	0.87	1.34	0.10	1.28	1.00
Uttar Pradesh	0.68	1.31	0.38	1.73	0.94
National Avg	0.76	1.52	0.13	1.27	0.88

Source PFC (2020)

1. **Subsidy rationalization for all the consumers:** The National tariff policy 2016 caps the prevailing cross subsidy to ± 20% of Average Power Purchase Cost (APPC). The impacts of cross-subsidy phaseout if passed directly to the consumer categories will be two-fold. For subsidized consumers primarily agricultural (~90%) and a large section of domestic consumers, it will mean substantial increase in electricity tariff. Contrarily, industrial and commercial consumers will gain as their output cost will reduce making them more competitive. Figure 8.5 provides existing differences for consumer tariffs from average cost of power purchase.

The impacts of cross-subsidy rationalization were studied on energy consumption pattern and sectoral output for different consumer categories at regional level under high renewable efficiency pathway. Two set of scenarios are constructed (i) moderate reduction in subsidy and (ii) Subsidy rationalization of −/ + 20% as proposed in National Tariff policy.

As detailed in Table 8.8, in both the scenarios subsidies for Industrial, Commercial and other consumers are capped at 20% higher than APPC and domestic consumers at APPC. In states of Karnataka, Madhya Pradesh and Maharashtra domestic consumers pay higher than APPC tariff so the price of electricity will reduce for domestic consumption in

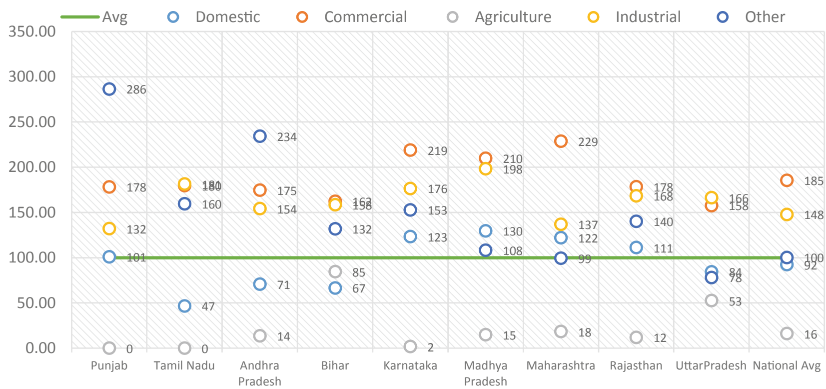

Fig. 8.5 Existing percent tariff difference from average power purchase cost (*Source* Author's compilation from PFC Report [2019])

these states. In the moderate scenario agricultural consumers pay 15% of APPC and domestic consumers pay as per APPC. In subsidy rationalization scenario agricultural consumers pay 80% of total APPC. In case of Bihar and Uttar Pradesh, the agricultural tariff already accounts for 85% and 53% of APPC and the values have been retained in the moderate scenario.

2. Direct Benefit transfer to agricultural and domestic consumers

The cross-subsidy phaseout is also augmented by proposition of direct benefit transfers to the subsidized agricultural consumer for better subsidy targeting, prospects of efficient energy use and increase in household disposable income and consumption. The existing pattern of landholdings and rampant ownership issues makes designing an effective DBT scheme for provisioning targeted subsidies to farmers a perilous task. Further, equitable allocation of incentives is a big issue due to disproportionate availability of irrigation infrastructure skewed toward large farmers. Within the total cultivated land prevalence of irrigation is highest in large and medium farmers (72–79%) with marginal farmers receiving only 45% of total irrigation facility (Dharmadhikary et. al., 2018). The table 8.9 details landholding patterns and percent area under cultivation across various states.

Even after the heavy subsidization of agricultural tariff, the total irrigated area under cultivation in India is only 48.8%. This indicates that lack of energy infrastructural still forms key barriers to extending pump irrigation in India. The total land under irrigation varies across region, for example a state like Punjab has already achieved 98% irrigation coverage with some other economically progressive states like Maharashtra and Karnataka being able to reach only 18.2 and 34.2%.

Table 8.8 Ratio of inputs for subsidy phase-out scenarios across consumers

	Agricultural	*Domestic*	*Commercial*	*Industrial*	*Others*
Moderate	0.15	1	1.2	1.2	1.2
Subsidy rationalisation	0.80	1	1.2	1.2	1.2

Source Authors calculations

Table 8.9 Landholding pattern and area under cultivation across states

State	*% irrigated*	*Total area (Th Hectare)*	*Large*	*Medium*	*Semi medium*	*Small*	*Marginal*
Andhra	50.5	8004	276	1038	2020	2334	2336
Bihar	68.7	6457	45	431	1076	1178	3728
Karnataka	34.2	11,805	861	2569	3188	3107	2080
Madhya Pradesh	43.1	15,607	933	4008	4522	3836	2372
Maharashtra	18.2	20,506	1162	4099	6026	5771	3449
Punjab	98.9	3954	857	1730	984	290	93
Rajasthan	42.0	20,873	6114	6899	3989	2389	1483
Uttar Pradesh	80.1	17,450	343	2075	3560	4157	7298

Sources Agricultural Census 2015–2016

E3-India provides a spread of 12 rural and 12 Urban household income categories. For creating scenarios to represent the direct benefit transfer for agricultural household, the existing agricultural subsidies to the power sector for each state was progressively employed to the five categories of farmers as specified in Agriculture census 2015–2016 (Government of India, 2019)—(i) large holding farmers; (ii) medium; (iii) semi-medium; (iv) small (v) marginal farmers—by indexing total irrigated land, proportion of irrigated land for farmer type. The five farmer categories were spread into 12 rural categories on the basis of land holdings proportions.

The impacts of subsidy phaseout on various consumer categories in terms of consumption and demand were mapped. This was also followed by mapping the macroeconomic impacts in terms of GDP and employment and income impacts for the scenario. The results are analyzed in the following section.

The impacts of subsidy phaseout will flow through the economy as two counterbalancing effects: (i) effect of reduction in cost of electricity for Commercial, Industrial and Other consumers; and (ii) steep increase in cost of electricity for agricultural consumers. The change in the cost of electricity generation (RE and efficiency interventions) also flows through the economy loop leading to decrease/increase in the input price of electricity for all sectors of the state economy.

The overall decrease in price of electricity for commercial and industrial consumers leads to increased demand for electricity, goods and services along with favorable impacts on household incomes. For agricultural and domestic consumers, price of electricity increases leading to reduction in demand, switch to cheaper fuels (diesel) along with subdued demand for goods and services.

The Fig. 8.6 details change in overall electricity consumption by states in the moderate and subsidy rationalization scenarios. The state of Punjab and Karnataka are most sensitive to increase in price of electricity, so even a modest increase in electricity cost leads to overall reduction in consumption primarily driven by reduction in demand from agricultural consumers. Punjab provisions free electricity to the agricultural consumers whereas Karnataka charges a marginal rate of 1% to the APPC along with comparatively lower cross subsidies imposed on industrial and other category consumers, therefore even a small tariff increase for agricultural consumers leads to reduction in overall consumption. The increase in consumption from subsidizing categories in these states undercompensate for reduction in agricultural consumption both for the moderate and rationalized scenario leading to an aggregate reduction in electricity use. Contrastingly for Andhra Pradesh-Telangana, Bihar, Tamil Nadu and Uttar Pradesh consumption of electricity increases for both moderate and rationalized scenario. In case of Tamil Nadu although agricultural tariff is zero but the total contribution of subsidizing consumers is more than 64% of total demand which leads to an increase in overall demand for electricity. In case of Madhya Pradesh and Maharashtra, the decrease in consumption for rationalized scenario is marginal with increase in consumption for the moderate scenario higher by 6–7%.

After analyzing the overall change in electricity consumption across states, we study change in energy mix associated with increase in cost of electricity in the agriculture sector. In the subsidy scenario, the proposed increase in electricity price is passed on to the agricultural and domestic consumers, the consumers resort to other sources of energy. Diesel generators are already mainstreamed for irrigation in India due to unreliable power supply and lack of rural energy infrastructure in many states. In the year 2010, the share of diesel pump irrigated area was over 80% in Bihar and between 50–55% in Madhya Pradesh and Uttar Pradesh (Ranganathan et al., 2016). Our results (Fig. 8.7) reveal that switch of energy use from electricity to diesel will be largest in states of Punjab, Maharashtra and Rajasthan. Tamil Nadu still sees a marginal decrease in oil consumption along with marginal reduction in electricity use indicating price inelastic demand for electricity in the state. The states of Uttar Pradesh and Bihar show a marginal switch as the agricultural electricity tariff is already high in these states and they already have much higher oil consumption as compared to electricity use (1.5 & 8 times respectively).

These scenarios provide a clear indication that options for passing over true procurement cost of electricity to agricultural consumers will lead to suboptimal development outcomes in terms of affordability of electricity for agricultural and domestic consumers. In case of domestic consumers, the impacts are mixed and align with the effectiveness of electrification programs for rural and urban consumers in the states. The states of Andhra Pradesh, Maharashtra, Uttar Pradesh and Rajasthan show a decreasing trend in oil use by domestic consumers primarily due to increased income for various household categories in 2030 (Fig. 8.7).

Streamlining prevailing subsidies and compensating certain section of consumers by direct benefit transfers is one of the awaited reforms in the power sector. Cost reflective tariffs are expected to reduce leakage (unaccounted distribution losses and thefts) and consolidate finances of power distribution companies. India has seen a widespread success of DBT program for LPG distribution for cooking purposes. The Government of India aims at developing effective DBT program for agricultural and domestic consumers one of which is to shift to cost-reflective tariff

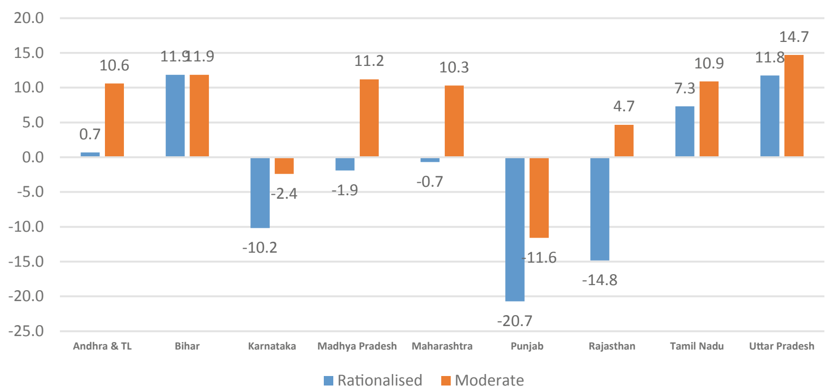

Fig. 8.6 Impacts of Cross subsidy phaseout on overall electricity consumption by 2030 (*Source* Results from the model)

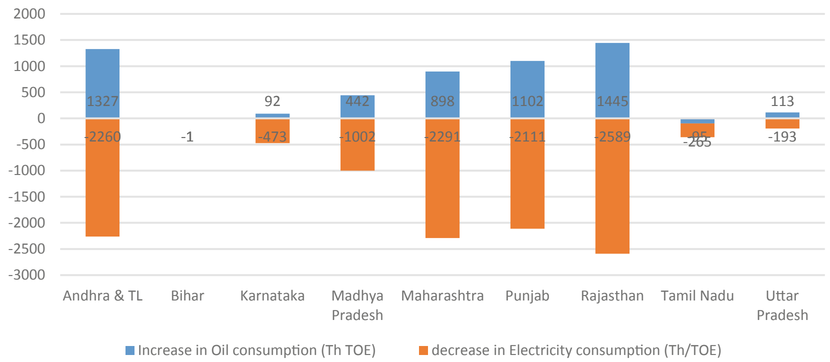

Fig. 8.7 Impacts of subsidy phase off on oil and electricity use for the agricultural consumers 2030 (*Source* Results from the model)

with commensurate cash transfer to households. We model the impacts of DBT transfer along with subsidies phaseout to better understand the impacts of subsidy rationalization across states.

8.5 Subsidy Rationalization with Direct Benefit Transfer (DBT)

We design a scenario to capture the effects of direct benefit transfers along with subsidy rationalization for the already constructed energy transition pathway. The scenario involved allocating cash transfers to various rural household categories as compensation for subsidy phaseout. The total subsidy amount was also separately allocated to the household consumption to map the impacts of direct benefit transfers on household expenditures.

We first estimated the total change in electricity consumption as the subsidy rationalization is compensated by DBT to households (Fig. 8.9). This is followed by estimation of change in agriculture outputs across the states (Fig. 8.8).

This is followed by an analysis of change on household energy expenditure. The results reveal that without any guidance and direction on the expenditure of direct benefit transfers, the consumption and expenditure on electricity only marginally increases across the states. The highest increase is seen for the states of Punjab, Rajasthan and Karnataka where the electricity consumption in subsidy rationalization scenario had significantly reduced (20–10%) although the commensurate increase in expenditure is only 1–2% higher than the baseline indicating diversion of DBT money to other household expenditures (Fig. 8.9). These results have to be understood with the caveat that for E3-India household expenditure are not differentiated into rural or urban categories but is split as a representative of single household. Though the impacts of increase in household consumption expenditure are captured in terms of increase in demand for goods and services.

The impacts on the agricultural output is marginal and overall positive for states of Andhra Pradesh, Bihar, Tamil Nadu and Uttar Pradesh for both subsidy rationalization and DBT scenario which is consistent with the overall electricity consumption trend. However, for states of Karnataka, Punjab the subsidy rationalization led to marginal reduction in output (−0.24%) which was compensated through DBT transfers toward a positive trend.

These results can only be interpreted as indicative of the overall impact on the agriculture sector. In reality the output impacts of increase in electricity price will vary according to specific crop and cropping pattern of a state. At present, E3-India model is limited in its capability to analyze these changes as the specification of agriculture sector is highly aggregated and consists of agriculture, animal husbandry and fishery outputs. The crop level disaggregation of agriculture sector as is available in Central Statistical Office (CSO) Input-Output Tables is not available (Kumar et al., 2012) in the model yet. The use of electricity for irrigation will be vital for the rabi or winter crops, but the Kharif or monsoon crop may not be impacted to a large extent. Further, the option for switch to already existing diesel genset is easily possible in states like Bihar and Uttar Pradesh further escalating emissions associated with agricultural fuel use in the states.

The results reveal that divergence of benefit transfers for other uses with increased use of diesel generators is a strong possibility if the agricultural consumers are exposed to cost-reflective power tariffs with DBT. Further, lack of infrastructure for metering and complex land ownership issues also make the power sector subsidy rationalization with DBT a difficult to implement proposition (Nirmal, 2020).

We further understand overall economic impacts for subsidy rationalization along with Direct benefit transfer by looking at GDP and employment impacts (Fig. 8.10) under business-as-usual scenario and

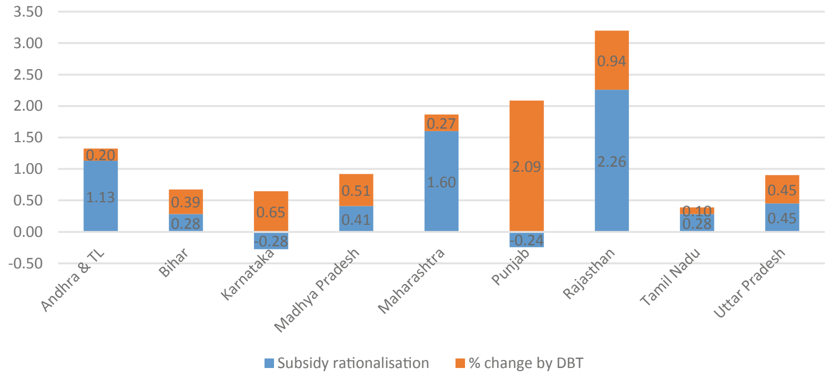

Fig. 8.8 Percentage change in agricultural outputs under subsidy rationalisation and DBT scenario 2030 in (%) (*Source* Results from the model)

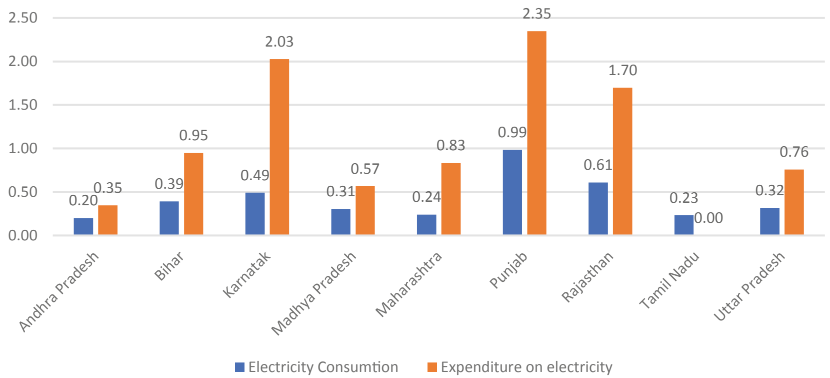

Fig. 8.9 Percentage change in electricity consumption and expenditure on electricity by households (2030) DBT in % (*Source* Results from the model)

integrated-subsidy rationalization along with high RE-high efficiency scenario. The results reveal that without an overlay of increased renewable generation and efficiency, the overall impacts on the GDP is negative except for Madhya Pradesh and Karnataka where impacts are positive.

Taking cognizance of these issues although Ministry of Power has provided a clarification for subsidy payment mechanism where its proposed to be given into the account of the consumers maintained

Table 8.10 Percentage change in electricity consumption across states with subsidy phase-out and direct benefit transfer 2030

State	*Rationalisation*	*Rationalisation plus DBT*	*Moderate*	*Moderate plus DBT*
Andhra Pradesh & Telangana	0.7	0.9	10.6	10.9
Bihar	11.9	12.3	11.9	12.3
Karnataka	−10.2	−9.7	−2.4	−1.9
Madhya Pradesh	−1.9	−1.5	11.2	11.6
Maharashtra	−0.7	−0.4	10.3	10.5
Punjab	−20.7	−20	−11.6	−10.7
Rajasthan	−14.8	−14.3	4.8	5.4
Tamil Nadu	7.3	7.6	10.9	11.1
Uttar Pradesh	11.8	12.1	14.7	15.1

Source Results from the model

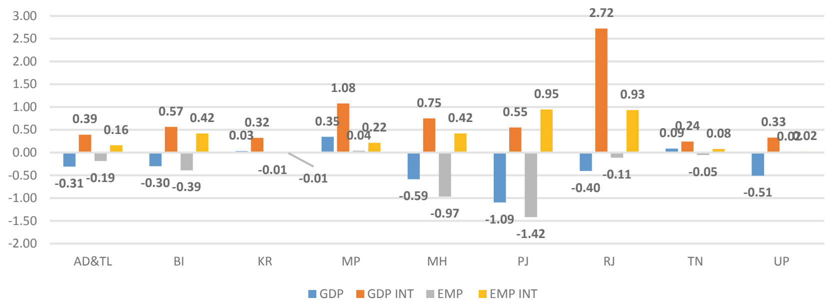

Fig. 8.10 Percentage change in GDP and employment impacts of subsidy rationalisation scenario 2030 (*Source* Results from the model)

by the Distribution Companies through DBT (Narayan, 2020). The State Governments are supposed to pay the subsidy in advance to the DISCOM/consumers as provided for in the law to avoid any financial burden on farmers directly. The mechanism of creating escrow accounts for DBT transfers would neither reduce the state subsidy burden, nor incentivize farmers to change their power consumption patterns and usage. Further, it would be difficult to implement the program without proper net metering facilities. Therefore, it's important that other more customized and pragmatic solutions for phasing out power subsidies are deliberated moving ahead.

We model the assumption of increased price of electricity for subsidized consumers as a counterfactual to quantify the impacts of increasing price of electricity for subsidized agricultural and domestic consumer to the proposed −20% of APPC. In reality it has been shown time and again that political economy of agricultural sector in the states do not favor subsidy removal from agricultural and domestic consumers. The intention of the analysis is to primarily understand the overall impacts of rationalization. The gained insights can help create more inclusive and sectorally integrated policies for the sector. Further as renewable generation and Distributed Energy Resources (DERs) are getting progressively cheaper and new alternatives are becoming available at an affordable price for provisioning electricity to remotely located consumers.

Along with the existing structural issues of economic and resource inefficiencies, the ongoing COVID pandemic will have a long-lasting impact on existing power sector transition trajectory in terms of demand security and future growth. The economic impacts of pandemic will also vary across sectors and states. We constructed a COVID impact scenario to better understand effects of COVID-19 pandemic on dynamics of regional economies and concomitant expected impacts on the proposed energy sector transition trajectory.

8.6 Demand–Supply Shock Due to Prevailing COVID Pandemic

The COVID 19 pandemic continues to spread rapidly in India and the trajectory of economic recovery is unpredictable. The Indian GDP contracted a record 23.9% in the quarter ended June 30, 2020 primarily due to the constrained economic activities during mega lockdown which adversely impacted consumer spending, private investments and exports (ET Online, 2020).

The extent of GDP constriction in the year 2020 has been projected in the range of -10.4% to readjusted estimates of −11.5% in 2020 by Moody’s rating agency (IMF, 2020; Scroll.in; 2020; ENS Economic Bureau, 2020) According to the pre-COVID estimates, the peak energy demand for India was expected to grow at a CAGR of 4.5% (CEA, 2019). A contraction in the economy will reduce the demand for electricity and will thus directly impact the investment projections for the power sector where capacity planning is undertaken keeping mid to long-term demand prospects usually published by the Government of India.

The recent study by TERI provides an estimate of 7–17% reduction in electricity demand in the medium term (Spencer, 2020). Most of the economic recovery estimates are modest estimating a negative shock in the FY 20–21 and thereafter normal or higher than normal recovery rates in key sectors like agriculture, industry and services.

COVID scenario was modeled to capture the impact of pandemic in near future on the regional growth trajectory. The scenario construction involved a combination of reduction in overall investments of upto 3% per annum and reduction in demand in terms of consumption expenditure (7-3%) in short term 2020–2023 leading to an overall reduction in GDP of the states. The results (Fig. 8.11) reveal that state GDP will recover after the initial shock between 2020–2023 however without a strong stimulus the pre-COVID simulated GDP level cannot be achieved. However, the investment in renewable energy and efficiency under proposed NDC targets help to bring down the gap by 2–0.2% across states. The greatest benefits are accrued in Rajasthan and Maharashtra where the renewable capacity addition is comparatively high. This provides a clear indication of effectiveness of green growth stimulus for effective recovery post-COVID pandemic. The total demand for electricity reduces in all the states in the short term.

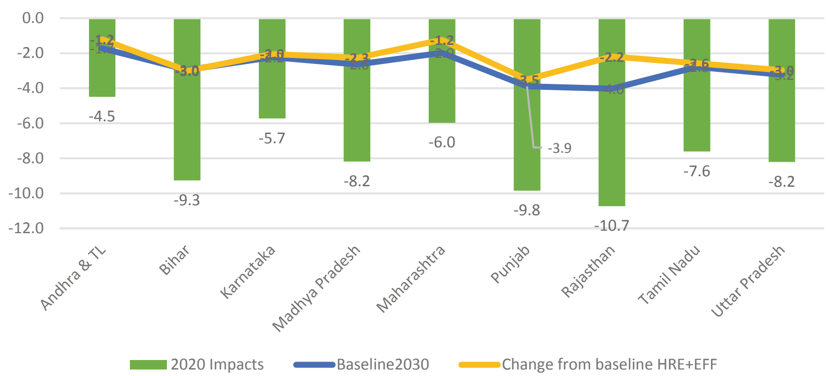

Fig. 8.11 COVID impact on GDP from 2020–30 (in percentage) (*Source* Results from the model)

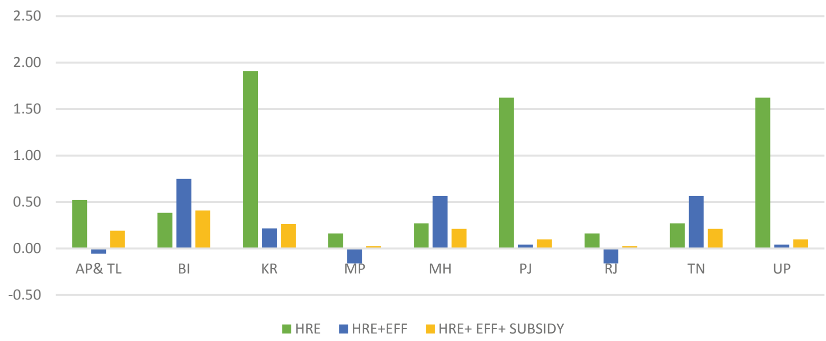

Fig. 8.12 Potential for COVID recovery through various interventions (*Source* Results from the model)

We further analyze the disaggregated impacts on COVID recovery (Fig. 8.12) and find that potential for rapid recovery from COVID by 2030 is highest by scaling up renewable capacities in states of Andhra Pradesh, Karnataka, Punjab and Uttar Pradesh and Rajasthan primarily driven by the investment impacts in the states whereas for Maharashtra, Bihar and Tamil Nadu incremental investment in efficiency measures along with renewables bring in fastest economic recovery.

In these states demand for energy is growing faster therefore significant negative investment impacts of efficiency scenario do not exist and further the states gain from diversified sectoral investment in efficiency equipment. Contrastingly in states of Andhra Pradesh, Madhya Pradesh and Rajasthan the efficiency measures lead to lower GDP levels than the baseline COVID recovery. Overall, the scenarios prove that concentrating efforts toward renewable scale-up and efficiency have a good potential for faster recovery not only at national level (CEA, 2019) by also at state level.

8.7 Integrated Scenario

Earlier we modeled four separate interventions pertaining to expected expansion of renewable energy, reduction in energy intensity, power sector subsidy rationalization and impacts of COVID 19 on the energy-economy at regional level. In reality all these interventions will simultaneously co-exist and can be modeled as an integrated scenario with the help of E3-India. Moreover, all the four policy interventions are characteristically different and will play out distinctly while moving through energy-economy trajectory. While RE addition is expected to bring in investment and economic growth, energy efficiency imperative works by reducing energy demand and concomitant investments in power sector along with greater efficiency investments across other sectors leading to mixed outcomes. While structural changes through subsidy rationalization are expected to bring better financial health for energy sector circling down to greater capability of the sectors to invest in incremental renewables and efficiency by being debt-free. However, they may constrain the affordability and access to power supply for rural India. The COVID impacts are generic and impacts the scale of all the above scenarios by putting constraints on demand across the economy.

The integrated scenario will capture combined and emergent impacts of all the interventions to provide the overall insights into dynamics of change in energy sector for individual states. E3-India allows us to track the changes for energy-economy-environment indicators simultaneously across time and region. The integrated analysis was designed to understand the emergent impacts regionally in terms of three key indicators representing Energy-Economy-Environment framework, i.e. change in GDP, electricity penetration rate and change in carbon intensity of electricity used across states from 2020 to 2030. Table 8.11 provides an outline for the analysis.

A trajectory that maximizes GDP and electricity penetration in the energy mix while minimizes carbon intensity of electricity use will be most

Table 8.11 Energy policy scenario description for state level integrated analysis

SCN description		*GDP*	*Electricity penetration in energy mix*	*Carbon intensity of electricity used*
SCN 1	High RE	State-wise % change 2020–2030		
SCN 2	High RE plus energy Efficiency			
SCN 3	SCN 2 + Subsidy rationalisation & DBT			
SCN 4	SCN 1 + SCN 2 + SCN 3 + COVID scenario			

discernible for all states. As a general trend across states we have already estimated in previous sections that high renewable capacity augmented with reduced energy intensity provides the most effective outcome in terms of maximization of GDP. Table 8.11 details a comparative profile for the four scenarios with respect to energy mix and change in carbon intensity. The proportion of electricity in energy mix for efficiency intervention is only marginally lower than high renewable energy scenario primarily due to reduction in overall energy use. Further, we also find that in developing states like Bihar and Madhya Pradesh, the energy penetration rate goes up by 20–41% between 2020–2030, this indicates greater access to electricity in the states with the proposed energy transition trajectory a highly discernible developmental outcome for these underdeveloped states.

The proposition of subsidy rationalization and DBT transfer reveals least beneficial primarily because both GDP and electricity penetration rates reduce for most states due to the introduction of cost-reflective tariffs. Furthermore, carbon intensity of electricity use goes up due to switch to diesel gensets. At the regional level we find that the impacts of subsidy rationalization with DBT transfer varies across the state. States like Andhra Pradesh, Maharashtra, Karnataka, Punjab and Uttar Pradesh show 8.2–21% reduction in the electricity penetration however for states like Madhya Pradesh and Bihar show a moderate change of 2–4%. In the case of Madhya Pradesh, the COVID scenario shows a positive spike as the demand for overall energy use reduces more than the demand for electricity during the COVID shock period (2020–2023) (Table 8.12).

The existing targets for nationally determined Commitments are also the key driver for the ongoing energy transitions at regional level. Minimization of carbon intensity of the energy use is one of the key outcomes to be monitored (CEA, 2019). We studied impacts of carbon intensity reduction for all the four scenarios (Table 8.13). We find that states possess distinct potential to reduce their carbon intensity of electricity input. The increase in RE capacity is the most effective option leading to an average reduction of carbon emissions between 59.04% for Bihar to 3.57% for Maharashtra. The emissions for Punjab increase for all the scenarios by 2.28–9.93% as RE potential for the state is low and it has new coal capacities in operation. In case of Bihar the emission reduction potential for subsidy rationalization scenario is more as the electricity price marginally reduces due to subsidy rationalization from existing 0.83% of

Table 8.12 Comparative impacts on electricity penetration and carbon intensity of electricity mix in 2030

STATE	1	2	3	4	1	2	3	4
	% Electricity Penetration in the Energy Mix				% change in Carbon Intensity of Electricity MIX			
AD	12.65	11.66	10.57	10.83	6.13	5.99	6.59	6.41
BI	4.05	4.03	3.64	3.82	11.05	10.98	10.52	10.41
KR	12.72	12.65	11.74	11.69	5.29	5.32	5.70	5.72
MP	11.87	11.83	11.56	11.69	4.97	4.96	5.00	4.95
MH	9.51	9.46	8.81	8.87	8.41	8.45	9.03	8.95
PJ	12.15	12.10	11.45	11.96	6.44	6.46	6.82	6.44
RJ	11.95	11.87	10.70	10.95	5.46	5.48	6.52	6.48
TN	8.52	8.46	6.71	6.76	5.67	5.69	6.18	6.05
UP	12.22	12.15	11.16	11.18	5.46	5.48	6.52	6.48

Note: (1) High Renewable Trajectory (HRE), (2) HRE + EFF; (3) HRE + EFF + SUBS_DBT; (4) HRE + EFF + SUBS_DBT + COVID
Source Results from the model

Table 8.13 Percentage change in carbon intensity across state between 2020–2030

SCN	*AP*	*BI*	*KAR*	*MP*	*MH*	*PJ*	*RJ*	*TN*	*UP*
1	−6.12	−59.04	−7.13	−35.48	−3.57	2.28	−18.17	−6.73	−9.51
2	−8.27	−59.30	−6.64	−35.57	−3.11	2.61	−17.88	−6.27	−9.11
3	−5.66	−62.66	−1.37	−34.93	4.14	9.93	−7.24	−3.75	−6.16
4	−8.49	−63.30	−0.55	−35.50	3.46	5.06	−7.02	−6.03	−6.27

Source Results from the model

APPC to 0.80% of APPC. The results also reveal that in subsidy rationalization scenario large state like Maharashtra will revert their carbon emission trajectory from emission reduction of 3.57% to an increase of 4.14% by 2030. These results provide a strong counterfactual that moving ahead without creating greater synergies between national level high renewable-efficiency and subsidy rationalization policies, the requisite environmental performance towards Nationally Determined commitment cannot be achieved. There will be significant leakages in terms of greater diesel consumption in most of the states.

For instance, provisions of recurring subsidy can be replaced by options of one-time capital subsidy for providing reliable energy infrastructure to remote farmers. Some alternatives have been tried in states of Maharashtra, Rajasthan and Gujarat. In Maharashtra solar feeder scheme has been adopted where substation size solar power plant has been developed on public-private partnership. In Rajasthan off-grid solar irrigation scheme has been launched for farmers who cannot be provided the electricity supply by grid extension (Gupta, 2019). In the state of Gujarat, grid connected solar irrigation has been piloted, where excess electricity can be stored to the grid under Gujarat Surya Shakti Yojana (SKY) (Jani, 2018). In June 2019, the Government of India launched a scheme called "Prime Minister Kisan Urja Surakhsha evam Utthan Mahabhiyan" (KUSUM A-C) which combined all the three models under one scheme (MNRE, 2019). KUSUM A-C provides for solar feeder PPA model with Discoms obligated to purchase through 25-year PPA along with the must-run status, KUSUM B aims at replacement of existing diesel agriculture pumps up to the capacity of 7.5 HP in areas where grid supply is not available. The state and central government provide a combined capital subsidy of 60% with farmers contributing rest 40%. In KUSUM C farmers are conceptualized as prosumers and are allowed to sell the surplus electricity to the grid.

These schemes provide a snapshot of constructive alternatives available to existing reality where a state will be able to stack up and leverage the benefits of renewable scale-up, energy efficiency and the opportunity to reduction of power sector deficit along with state power sector subsidy budgets through energy transitions. The evaluation of these policies under the larger contexts of emerging technology frontiers and discernible sustainable policy outcomes can help alleviate some of structural rigidities associated with the tariff design and reliable power supply. This analysis is first step towards initiating such deliberations.

8.8 Conclusions

The existing national-level energy policy interventions targeting renewable scale-up and energy intensity reduction to meet the existing NDC commitments for India have an implicit potential for better socioeconomic outcomes by driving economic growth while decarbonizing the energy mix. However, the scale and scope of leveraging these benefits vary across regions and are a direct function of state-specific energy-economy geography along with prevailing political realities. A prudent design of transition trajectory will be critical for effective implementation of policies that can harness benefits from emerging techno-economic frontier for new energy technologies.

A regional assessment of the four interventions reveal some key insights for the policymakers. The Southern states of Andhra Pradesh & Telangana, Tamil Nadu and Karnataka add over 131 GW of renewable capacity by 2030 and reduce over 6 GW of coal generation by year 2030. However, overall change in GDP and employment is marginal due to a relatively large economic size. The performance of economic indicators improves under efficiency interventions. The power sector subsidy rationalization leads to marginal reduction in GDP and employment but increases use of fuel oil in the energy mix by 2.4%. At present reduced demand in the power sector due to COVID impacts is adversely impacting its aspired growth trajectory. We find that the greatest recovery potential in the short term is offered by increasing the renewable energy capacity installation in the region. Moreover, options for energy efficiency improvements marginally constrains the recovery path for Andhra Pradesh and provides only marginally potential for additional recovery in case of Karnataka. However, for Tamil Nadu, efficiency plus scenario provides the maximum benefit. Thus, the pathway for an effective recovery lies in accelerating renewable scale-up followed by efficiency. Starting afresh the southern states should consider prospects of effective sector coupling and other focused interventions like promoting distributed generation in rural areas for harnessing greater socioeconomic benefits.

The Western and Central states of Maharashtra and Madhya Pradesh provide a unique combination of distinct economic status but overlapping energy geographies. The region adds over 61.7 GW of renewables which is equally distributed and reduce 2.23 GW of coal from its energy mix by 2030. However, the additional GDP growth is marginal for Maharashtra as compared to Madhya Pradesh primarily a function of economy size[3] and contribution of power sector in state GDP. However, proposition of efficiency investments along with high renewable pathways leads to much higher economic benefits for Maharashtra where GDP and employment increases by more than 1% whereas for Madhya Pradesh its only marginally high. The subsidy rationalization scenario leads to noticeable reduction in GDP and employment for Maharashtra, furthermore its energy trajectory gets carbon-intensive with an increased emission of over 4.4% by 2030. Contrastingly, Madhya Pradesh reveals a slight increase in economic growth primarily driven by greater availability of cheaper power to C&I consumers. The state of Maharashtra is one of the worst-hit in terms of the COVID pandemic. Unlike other states, the state reveals a unique opportunity towards fastest economic recovery by scaling up incremental efficiency improvement measures. The state has relatively large electronics and electrical equipment sector which can help in rapid recovery for the state economy. State government should therefore, further facilitate investments in efficiency measures across the state. In case of Madhya Pradesh, high renewable pathways shows maximum recovery potential so state government should ensure a better environment for greater renewable growth by improving liquidity conditions and sector coupling measures as initiated through new state solar park policy.

The north-western states of Rajasthan and Punjab although share a boundary but have disparate energy geographies. The state of Rajasthan has the largest solar potential and moderate wind potential whereas the overall renewable potential for Punjab is low. In the high HRE scenario, Rajasthan adds 40 GW of renewable capacity as compared to just 4.4 GW for Punjab by 2030. The high renewable trajectory is beneficial for Rajasthan. The potential of economic growth through promoting efficiency measures is large in both Rajasthan and Punjab leading to increase in GDP and employment. Income and employment effect for efficiency scenario is much higher in case of Punjab due to increased investments in agriculture, electric supply, motor vehicle and electrical and electronics sector by 2030. Both states are highly sensitive to the provisions of subsidy rationalization. The state of Punjab reveals over 20% reduction in electricity use even under DBT facilitation scenario and for Rajasthan its 14.2% along with concomitant reduction in GDP. The provisions for

[3] The SGDP for Maharashtra is highest in India and is more than three times the GDP of Madhya Pradesh.

renewable capacity scale-up provide the fastest COVID recovery potential for both the states with efficiency measures leading to slight reduced outcome for Rajasthan. These results provide a clear evidence that levying cost-reflective tariffs will not only make electricity-based irrigation cost-prohibitive for farmers in these states but will not be a prudent strategy to rejuvenate economic growth. The steep decline in cost of renewables and its suitability for the end users to generate electricity directly without greater dependence in grid can change the dynamics of energy access and provisioning electricity in remote rural area in this region and state government should focus toward more comprehensive policies which club greater livelihood opportunities with reliable energy access for better developmental outcomes.

The North-western state of Uttar Pradesh and Bihar provides a unique combination with comparatively lower renewable generation potential but high future demand potential. The per capita availability of electricity for Uttar Pradesh and Bihar stands at 606 kWh & 311 kWh respectively, one of the lowest in India. These states fence a lower position in economic growth index and therefore investment in energy infrastructure expansion and electricity provisioning will not only bring economic growth but also relatively better developmental outcomes. Moreover, their standing in terms of power generators is very different. The state of Uttar Pradesh is a net exporter of electricity with over 18.2 GW of thermal capacity largely central government-owned capacity and supplies to neighboring demand center like Delhi. Contrastingly Bihar has very small generation capacity of 5.3 GW and has been importing electricity from hydro plants in neighboring states and also procuring through open markets since the sector restructuring. It has been one of the laggard states in terms of renewable capacity addition, but as solar capacity becomes progressively cheaper, we see a strong potential to build a better and greener developmental trajectory can be a reality for Bihar.

We modeled an ambitious RE policy in both the states to understand the change in overall dynamics of energy use due to renewable energy transitions. The total added renewable capacity in the region stood at 28.04 GW and see a reduction of over 5.9% in coal generation from the baseline. The overall increase in GDP and employment for efficiency intervention is moderate. The greatest distinction in impacts are observed for the subsidy rationalization scenario. Uttar Pradesh and Bihar are the best performers for increase in renewable energy mix. However, these states have comparatively higher agricultural tariff as compared to other states therefore the subsidy rationalization proposition brings in larger benefits in terms of increased consumption of electricity. The impacts of subsidy rationalization on GDP is negative for both the states with the performance of economic indicators improving only when green interventions of high renewable and efficiency are added. Further, the greatest COVID recovery potential lies in efficiency plus scenario for Bihar but in increasing renewable energy capacity when it comes to Uttar Pradesh where efficiency will reduce greater investments from the power sector than efficiency investments can compensate. The high renewable with efficiency trajectory offered through NDC targets provide a unique opportunity to build it right the first time for states like Bihar and Uttar Pradesh where status of rural energy infrastructure is dismal. The state governments should design integrated and innovative policies which allow them to leverage the progressive benefits from distributed energy systems and energy efficiency programs for ensuring clean, affordable and reliable energy. Our analysis already shows that going in this route will have greater economic benefits and growth potential in medium to long term.

The reality for the Indian energy sector will be informed by both the emerging technology frontier enabling greater and more efficient use of renewables but also by structural changes emanated through proposed electricity reforms. Further, the existing COVID pandemic may change the small to medium-term demand estimates and cost dynamics for the power sector. In absence of really strong positive stimulus, recovery to pre-COVID levels is prohibitive. However, reallocating investments toward green recovery (IANS, 2020) can help bridge the gap and also lead to better socioeconomic outcomes both nationally and at regional level. However, one size fit all solutions will not work. Recovery and growth prospects of the existing energy transition trajectory will have to be strategically designed for the discernable socio economic outcomes. The effective regional policies will thus need to articulate policy measures to maximize the benefits offered by new emerging technologies in a way that not only avoids future carbon lock-in but also provide options for economic growth and ensures energy security for the region.

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CHAPTER 9

Managing Delhi's Air Quality: Exploring Economic Implications of Airshed Management Approach

Ranjit Bharvirkar, Hector Pollitt, and Surabhi Joshi

9.1 Introduction

In the last decade, major Indian cities—especially, those located in northern India including the national capital territory of Delhi (referred to as NCT in the rest of this chapter)—have achieved the dubious distinction of being the most polluted in the world (IQAir, 2020). NCT and surrounding National Capital Region (Image 9.1) are one of the most

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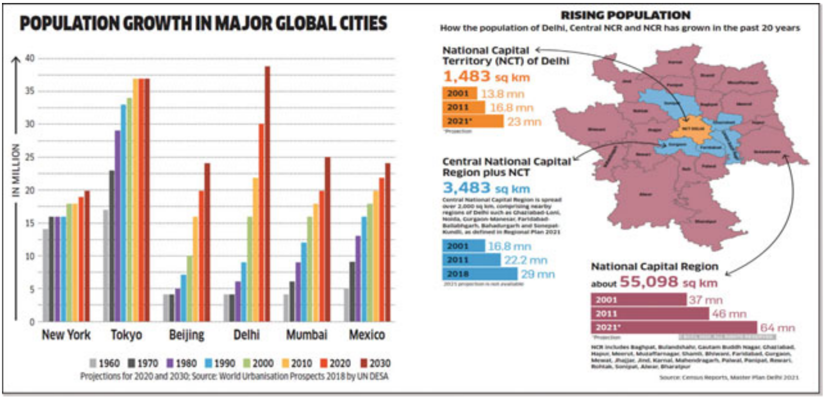

Image 9.1 Population growth in and around National Capital Territory (*Source* Sharma, S. N. [2019])

rapidly growing urban sprawls in India (Koppikar, 2016), heading toward becoming world's most populous city agglomerate by 2028 (UN, 2018).

According to a Lancet study published in 2018, the annual population weighted mean exposure to $PM_{2\cdot5}$ in India was 89·9 $\mu g/m^3$ in 2017—greater than 40 $\mu g/m^3$, which is the limit recommended by the National Ambient Air Quality Standards in India (Dandona, 2019). In year 2019, Delhi recorded the highest average annual $PM_{2.5}$ levels of 98.9 $\mu g/m^3$ among world regional capitals (IQ Air, 2020). The World Health Organization estimates that 4.2 million premature deaths globally are linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children (WHO, 2020). The State of Global Air 2020 report indicates that India had the highest burden of infant deaths due to air pollution; over 116,000 infants in India died within a month after their birth due to exposure to severe air pollution in 2019 (HEI, 2020).

According to the World Bank, at a global level the cost associated with health damage from ambient air pollution is estimated to be \$5.7 trillion, equivalent to 4.8% of global GDP (World Bank, 2020). Unplanned urban growth along with mounting population pressures makes NCT a hotspot of deteriorating air quality and concomitant morbidity. Yet, there is limited—if any—effort to address this issue from policymakers.

Faster deterioration of air quality in the NCR makes it highly susceptible to pandemics and alleviated ozone levels (Sati & Mohan, 2017). Latest study by Indian Medical Association attributes 13% of new COVID pandemic cases in the region to ongoing severe deterioration in air quality post opening of the nationwide lockdown (The Wire, 2020).

The year 2020, although, did make us witness a rare binary where in the third week (April 2020) of the pandemic-induced national lockdown, citizens of Jalandhar in Punjab woke up to the wonderful sight of the Himalayas that are located ~ 100 miles away (Picheta, 2020). Such a sighting had been unheard of for more than three decades. Reports from all over India described the marvelously clean air that most citizens were experiencing for the first time in their lives. Figure 9.1 details air quality conditions pre- and post-lockdown in Delhi.

This feat was achieved by the total nationwide shut down of most human activities for more than a month. Most major polluting sources such as transportation, construction, and others were either partially or completely shut down (Guttikunda, 2020). With the pandemic still continuing at the time of writing, the economic impact of this total nationwide shut down is still being assessed. Instead of experiencing another year of economic growth, various agencies are estimating that the Indian economy will contract by 9–12% (Mishra, 2020).

This real-world and ongoing experiment suggests that improved air quality and the commensurate health benefits (and associated economic

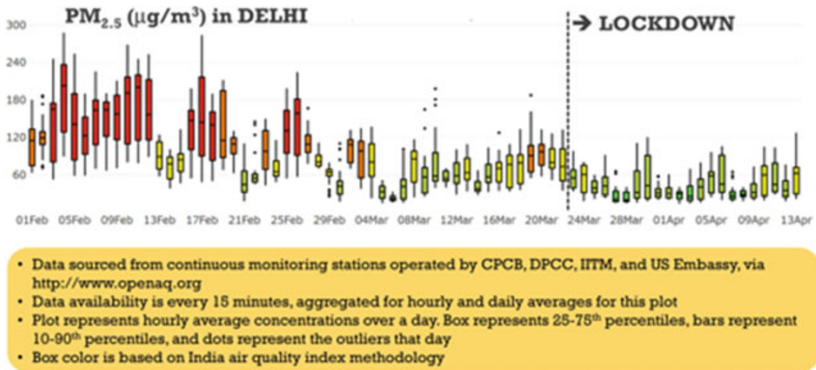

Fig. 9.1 Air quality monitoring in Delhi pre and post-lockdown (in µg/m^3) (*Source* Urban Emissions [2020])

benefits) may force India to confront the trade-off of high economic costs incurred through lower economic growth, rising unemployment, and falling incomes. In this chapter, we attempt to assess these trade-offs systematically in a disaggregated (e.g., state, sector, income category, etc.) manner.

An understanding of existing interlinkages between drivers of economic growth, sources of air pollution and existing interventions for improving air quality in the national capital region will be critical for designing any effective air quality management program. The sources of air pollution in India are myriad, ranging from coal-based thermal power plants (referred to as TPPs) to individuals burning small amounts of garbage in residential neighborhoods. Further, they vary by region. At a qualitative level, there is a robust understanding of the key sources of pollution even though there is a very high degree of uncertainty regarding the exact contribution of each source of pollution and more importantly, the impact of the pollution on health.

Ever changing meteorological conditions—e.g., prevailing wind patterns, precipitation, ambient temperature, etc.—has major implications for both the transport and transformation of emissions from various sources into specific health impacts. Sophisticated numerical models that, typically, require an extremely high level of computational power—e.g., super-computers—are necessary for establishing the connection between the emission source and the health impact (Guttikunda et. al., 2019).

A key component of air pollution impact analysis is how it is transformed subject to meteorological and geographical aspects of the region. The technical term that combines both the meteorological and geographical aspects—is "airshed" (Khanna & Sharma, 2020). The Delhi Capital region has a unique distinction of not only being an air quality hotspot that emanated out of increased urbanization and rapid migration of population to urban agglomerate, but also as a meteorological zone with limited capacity to process air pollution specifically during winters. The Delhi airshed is known to have distinctly different meteorological conditions during summers and winters. October marks withdrawal of monsoon in North western India and direction of wind changes from Easterly to Westerly carrying dust and long-range transport of particulate matter from Rajasthan and even as far as Pakistan and Afghanistan. According to a study by National Physical Laboratory, 72% of Delhi's wind in winters come from northwest while remaining 28% from Indo Gangetic plains (Joshi, 2020). Coincidently the phenomenon is also coupled with higher agrarian activity in the North Western states with harvest season coupled with intensive stubble burning which adversely impacts the air quality of landlocked regions in the airshed. Studies show that long-range dispersion of pollutants from the west leads to 9–57% contribution of the total $PM_{10-2.5}$ mass during different seasons (Pawar et al., 2015). Recent emission source apportions studies point at 4 major source of air pollution in Delhi, industry, transportation, biomass/waste burning, and dust—see Fig. 9.2 and Table 9.1.

Within each category we focus on major sources as follows:

1. *Dust—construction activity*. Dust primarily from construction activities contributed over 16% of $PM_{2.5}$ loading in winters for NCR primarily attributed to extensive construction activity within the region. Pre-COVID projections attribute NCR with highest real estate growth in India specifically in residential, commercial, and hospitality space (IBEF, 2019). The policy considered here is reducing construction activity during bad air quality episodes (e.g., as NCT has already attempted in 2019). We also consider an augmentative policy of increasing green cover as an alternative to simply banning construction activity.
2. *Transportation—vehicles*. Vehicles contribute over 30% of $PM_{2.5}$ loading in winters for Delhi. The number of registered vehicles

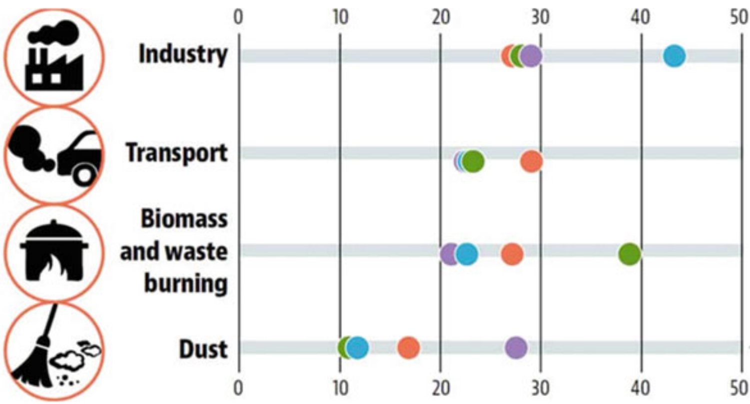

Fig. 9.2 Major sources of pollution in Delhi (in percentage) (*Source* Dubash and Guttikunda [2018])

Table 9.1 Literature review on emission sources in NCR and Delhi

Sr. no		*Location*	*Method*	*Source apportionment studies*	*Studies on emission sources*
1	IIT Kanpur (2016)	Delhi	Top-down	Based on Urban Emissions' re-interpretation of Sharma and Mukesh (2016), which redistributes secondary particles	**Industry**—It is a fuel-based study. The coal estimate is used for industry; hence diesel generator sets are not included but are reported under transport for this study **Transport**—Diesel and Petrol categories are used, which may overestimate transport since it included diesel generator sets **Biomass and waste burning**—Includes municipal waste burning only
2	CPCB (2011)	Delhi	Top-down	Based on Urban Emissions' re-interpretation of CPCB (2011), which converts PM_{10} and $PM_{2.5}$ data	**Biomass and Waste Burning**—Include municipal and commercial waste
3	TERI and ARAI (2018)	NCR	Bottom-up	Based on averages of summer and winter seasons (not 12 months)	**Biomass and Waste Burning**—Include municipal and commercial waste **Dust**—The study says dust is a higher share of emissions in summer (38%)
4	Urban Emissions (2018)	NCR	Bottom-up	–	–

Note SAFAR (2018) not included because it is an emissions inventory rather than a source apportionment study
Source Dubash and Guttikunda (2018)

in NCR is growing at 7–9% per annum. Further, there is heavy incoming traffic of vehicles from neighboring states of Punjab, Haryana, and Uttar Pradesh for trade and other reasons on daily basis, contributing significantly to vehicular emissions in the region. We consider a policy of substituting vehicles that use petrol and diesel with electric vehicles for all the four states. Policy that reduces the use of vehicles and the number of vehicles is not considered even though tire degradation and dust from roads are also considered major sources of air pollution.

3. *Biomass and waste burning—paddy farms*. Biomass and waste burning on an average contributes over 23% of $PM_{2.5}$ loading in winters for NCR. However, the winter peak loading $PM_{2.5}$ due to stubble burning in Punjab, Haryana, Uttar Pradesh, and Uttarakhand was estimated to be 42% on Nov 5, 2020 (*The Economic Times*, 2020). Therefore, the only policy considered here is reduction in burning of rice stubble in paddy farms post-harvest by implementing strategies such as Happy Seeders and using rice stubble for productive uses such as biomass-based electricity generation and manufacturing cardboard. Policies that target other waste and biomass burning are not considered in this analysis due to lack of sufficient underlying data.
4. *Industry—power sector.* NCT has 13 thermal power plants with a capacity of over 11,000 MW within a 300-km radius and coal, fly ash, and secondary particles from thermal power plants often blown into the NCR by the northwesterly winds contributing significantly to $PM_{2.5}$ levels in winter (CPR, 2018). We considered two policy options of installing air pollution control equipment on sources such as coal power plants and substituting coal power plants with renewable energy plants (e.g., solar and wind). Other industries are not included in this analysis as there are no techno-economically proven ways to reduce air pollution from many of them.

Some of these emission sources can simply be replaced by clean technologies—e.g., solar/wind for electricity generation instead of coal, and electric motors running on batteries instead of internal combustion engines for transportation. However, there also exist technologies that can reduce the emissions without such replacement. For example, emissions from fossil-fired power plants can be controlled through the use of mature and easily available technologies such as electrostatic precipitators (for particulate matter), flue gas desulfurizers (for SO_2), selective catalytic reduction (for NO_X), and washing coal (for ash) while catalytic converters are available for eliminating tailpipe emissions from internal combustion engines.

Emissions from sources such as biomass/waste burning cannot be controlled as there is no single point source (e.g., smokestack in case of power plants or tailpipe in case of internal combustion engine). The need for combustion can be minimized through strategies such as use of Happy Seeders for addressing rice stubble waste. Experts have also suggested that paddy farming can itself be reduced thereby reducing the problem of rice stubble. Increasing green cover—i.e., afforestation activities—can significantly reduce dust. Construction activities can also deploy strategies such as using water to settle dust down and installing covers over the construction activity to contain the dust.

Some of these approaches to reducing emissions have incremental costs that the entities that are responsible for those emission sources have to incur. These incremental costs could lead to lower profits if not outright losses for these entities as a result of policies that seek to reduce emissions. While the cost–benefit analysis—at a societal level—for the use of these emission reduction approaches is overwhelmingly beneficial as established by numerous studies conducted in many parts of the world, the stakeholder-level cost–benefit analysis is likely to create winners and losers.

As Dubash and Guttikunda (2018) assert that a majority (as high as 70 percent) of the air pollution observed in NCT is generated beyond the borders of NCT, we adopt an Airshed Management approach—i.e., applying policies to not just the NCT but also its neighboring states such as Punjab, Haryana, and Uttar Pradesh.

Taking cognizance of deteriorating air quality in Delhi NCR, the supreme court of India in 2019 took governments of the states Punjab, Haryana, Delhi, and Uttar Pradesh to the task for not being able to control the life-threatening pollution in the combined region. Usually, a successful airshed management will entail multilevel air quality governance and effective enforcement regimes. State of Delhi came up with a comprehensive Graded Response Action Plan (GRAP) notified in 2017. GRAP requires implementation of actions by respective state authorities and coordination among 13 agencies of Delhi, UP, Haryana, and Rajasthan. Table 9.2 provides the details of GRAP implemented by NCT starting October 15, 2020.

Table 9.2 Graded Response Action Plan implemented in National Capital Territory—2020

Air Quality Category	*Actions*
Severe + or Emergency Category Air Quality (When PM 2.5 over 300 cubic metre or PM10 over 500 cu.m. for more than 48 h is recorded)	No entry for trucks into Delhi; only trucks carrying essential commodities allowed Stop Construction work Introduction of odd/even scheme for vehicles Task Force decides additional steps such as closing of schools
Severe Category Air Quality (PM 2.5 over 250 cu.m. or PM10 over 430 cu.m. is observed)	Closing of brick kilns, stone crushers and hot mix plants Maximisation of power generation only from natural gas to minimise generation from coal Encourage public transport Frequent sprinkling of water on roads
Very Poor Category Air Quality (PM2.5 of 121–250 cu.m. or PM10 of around 351–430 cu.m. is recorded)	Ban on use of diesel generator sets Increase parking fee by 3–4 times Increase bus & metro services Discourage burning fires in winters in apartments Movement of people outside to be restricted for people with respiratory or cardiac conditions
Moderate to Poor Category Air Quality (PM2.5 of 61–120 cu.m. or PM10 of 101–350 cu.m.)	Fine on garbage burning Enforce pollution control regulations in brick kilns & industries Mechanised sweeping & sprinkling of water on roads Ban on firecrackers

Source Pruthi (2020)

Most actions for emissions controlled under GRAP try to reduce the activities in key economic sectors, i.e., transportation, construction, combustion of fossil fuels—e.g., fossil-fired power plants (coal, natural gas, oil), internal combustion engines (diesel, petrol, and natural gas), diesel genset, biomass and waste burning, industrial processes, etc. create pollution. Additional sources of pollution include fugitive emissions (e.g., dust) from activities such as construction. We focus on the quantification of the economic impacts of controlling emissions from various sources.

The dynamics between the winners and losers influences the relevant policymakers when it comes to designing, implementing, and enforcing policies. For example, in 2015, Indian policymakers announced specific policies to reduce emissions from coal-fired power plants. A compliance period of two years was provided. At the end of the compliance period, it was clear that limited progress toward compliance had been made that resulted into litigation. In 2018, the Indian Supreme Court extended the compliance period to 2022 including specific milestones. As of November 2020, none of the relevant milestones have been achieved while the likelihood of compliance by 2022 is extremely low. Further, some of the stakeholders have started making a case for further extension (Dahiya, 2020).

The primary reason for non-compliance stated by the affected parties—i.e., owners of coal power plants—is that the incremental cost that they have to incur for installation of the pollution control equipment may not get reimbursed by the buyers of the electricity they produce (i.e., chronically loss-making distribution companies referred to as Discoms). In fact, Discoms have not been making full and on-time payments to electricity generators for a long time and hence, no bank is willing to even provide loans to the coal power plants for undertaking this new investment. The steadily deteriorating economics of coal power relative to new sources such as wind/solar and the diminished use of electricity because of the overall economic slowdown that pre-dates the pandemic has even raised the question whether it is better to simply retire coal plants immediately instead of spending more money on them (Fernandes, 2020).

In this chapter, our goal is to illustrate the application of the economic impact analysis methodology to a specific airshed—the National Capital Territory of Delhi (NCT). E3-India model is used to quantify potential economic benefits of integrated management and commensurate reductions in emissions from fossil fuel-based combustion. In recent years, increasing resources are being allocated for comprehensive data collection and development of sophisticated models for robust quantitative understanding of the sources of pollution and their health impacts. This chapter assesses how emerging options of trading clean electricity, coordinated regional policies for integrated management of power generation, vehicular emissions, construction, afforestation, and agriculture sector can help improve both air quality while also reducing the greenhouse gas emissions at regional level.

Each of these sources of pollution is complex and deserves a comprehensive treatment individually as presented in the discussion about coal power plants earlier in this section. For example, to reduce air pollution from TPPs one can consider policies that consist of consumer-focused energy efficiency. Similarly, for transportation, policies that focus on shifting passenger transport from individual vehicles (e.g., cars and motorcycles) to mass transit should be considered. The agricultural economy—especially, pertaining to a major crop such as paddy—is incredibly complex where policy levers such as international trade, water management, minimum support prices, market structures, and others can all contribute to a reduction in paddy cultivation. The construction sector can also be targeted with custom policies that go beyond—e.g., construction practices and materials—the blunt instrument of banning it for defined periods of time.

What is unequivocal is that all four sources of pollution also happen to be the building blocks of any economy. We don't want to leave the reader with the wrong impression that in this chapter we have been able to comprehensively represent the full range of policy levers that can be deployed to reduce air pollution from these four major sectors of the Indian economy. Our objective is to illustrate how E3-India can serve as an important tool in developing a deeper and more nuanced understanding of the linkages of these sectors with the broader economy and the distribution of the economic impacts across politically defined geographical units (i.e., states) and economic sector.

We also recognize that the timing of this research is such that underlying conditions are changing quite rapidly—e.g., India recently created a new policy framework for the agricultural sector that is being contested by key agricultural states such as Punjab. Harish et al. (2019) continue to advocate for a nationwide comprehensive multi-year approach for improving air quality (Harish et al., 2019). We encourage researchers to build on the analysis presented in this chapter in terms of both extending and updating it regularly as the overall global economic situation evolves during the ongoing pandemic.

This tussle among various key stakeholders—i.e., public health experts, environmental advocates, electricity consumers, Discoms, coal power plants, banks, electricity regulators, environmental policymakers, and courts spread out across multiple states—continues in the absence of robust quantitative analysis of the aggregate economic impacts and their distribution across various stakeholders. With such analysis, stakeholders will have a clear understanding of not just the winners/losers but also the size of the impact on each one of them. Stakeholders could then—potentially—explore strategies in which the winners could compensate losers in way that everyone is better off. The analysis presented in this chapter aims to fill in this analytical gap.

One can imagine a process in which development of stakeholder consensus is achieved through an iterative use of the E3-India model in a transparent and participatory manner over a period of time. For example, the newly announced Commission for Air Quality Management in National Capital Region and Adjoining Areas (CAQM) could establish a committee consisting of all relevant stakeholders and experts (Dubash et al., 2020). This committee could formally collaborate with a dedicated E3-India modeling team in order to develop a wide range of policy scenarios that would serve as a key input to the broader policymaking process.

Section 9.2 details the key inputs for scenario creation, analytical approach, and insights on key interlinkages modeled in the analysis. This is followed by delineation of key results and discussion for the eight distinct scenarios studied in the chapter in Sect. 9.3. The last Sect. 9.4 concludes and lists some of the limitations of the study.

9.2 Analytical Approach

The E3-India model is introduced in Chapter 2 of this book. The scenarios in this chapter use both the economic and energy modules within the model. Due to data limitations, E3-India does not provide estimates of air quality at state level, so we cannot assess the positive economic impacts of reducing pollution. Instead, we focus the analysis on the effects of the policies to reduce air pollution on economic activity. We modeled the following scenarios that reflect specific policy proposals that are currently under discussion in India. The detailed description of the model baseline is presented in Chapter 2.

We compare the baseline and scenarios with additional policies in an *ex-ante* analysis. In order to facilitate greater synergies and easy comparison with already existing research we calibrate the default model baseline such that the generation mix and electricity consumption at national level closely meet baseline estimates of a recently released energy transition commission report. The key reason for this calibration was to ensure that power sector scenarios are also aligned with the existing grid capacity projections till 2030. The details of baseline calibration are presented in Table 9.8 in the Appendix.

9.2.1 Dust Control Through Reduced Construction Activity

Construction is one of the key economic sectors in India and, especially, in the NCT. Under the Graded Response Action Plan (GRAP), construction activity is banned only under severe or emergency conditions when PM 2.5 concentrations are over 300 μg/m^3 or PM10 is over 500 μg/m^3 for more than 48 h. Until 10 February 2020, the Supreme Court had banned construction activity in NCT (Bhowmick, 2020). However, closure of other construction supply chain elements like brick kilns, hot mix plants, and stone crushers are mandated under even severe air quality deterioration conditions (PM 2.5 over 250 μg/m^{3}and PM10 over 430 μg/m^3) (CPCB, 2020).

During the initial months of the COVID-19 pandemic, there was a complete standstill of construction activity during the formal lockdown periods. The ongoing pandemic has constrained the revival of the sector due to limited availability of labor as a vast majority of labor migrated back to their villages during the lockdown and have continued to stay there. We expect that the pandemic—hopefully—ends in the near future and the construction sector, over time, regains its pre-pandemic level of activity.

In order to model the scenario of improving air quality by banning construction during bad air weeks, we reduce construction output by 20% until 2030 for all four states in the airshed. In other words, we assume that construction is banned for ~ 2.4 months every year during the winter season. For this scenario, we expect that the impact would be severely negative across most economic indicators as this is a major economic sector. Further, as air quality is a pertinent problem in the NCT, the probability of construction and allied activity to be banned annually during winters is very high. The objective—for this scenario—is to assess the magnitude of the economic impact in absolute terms while also serving as a benchmark for comparison with the other scenarios, along with exploring intersectoral linkages.

9.2.2 Urban Afforestation for Dust Reduction

Plants are known to scavenge significant amounts of dust from urban environment (Weyens et al., 2015). In Beijing (China) trees in the city center removed 772 tons of PM10 on a yearly basis and in Chicago, USA, trees occupy 11% of the city area and eliminate approximately 234 tons of PM10 per year (Yang et. al., 2005; McPherson et al., 1994). We model a generic scenario of increasing green cover—i.e., afforestation—which will create opportunities for new employment when construction activity is stopped and help in reducing the movement of dust through the region.

National forest policy of India since 1988 iterates the goal of bringing 33% of land area under forest and tree cover. Further, in year 2015, India has pledged to create 2.5–3 Billion tons of carbon sinks by 2030. The carbon sinks are to be created through programs such as National Afforestation Program, National Green India Mission, Green Highway Mission, National Agroforestry Policy, and others. As detailed in Table 9.3, the total land area under tree cover stands at 24.56% for India but only 2.89% of it can be attributed to rural and urban tree cover. We find that the NCT maintains comparatively much higher (approx. 3 times) tree cover when compared to states of Haryana, Uttar Pradesh, and Punjab. The states do have the bandwidth to create necessary incentives to enhance tree cover through various ongoing initiatives, specifically, in the urban pockets thereby improving carrying capacity in the Delhi airshed along with contributing to respective state climate actions plans.

Table 9.3 Tree cover across the Delhi airshed

	Area under forest cover (Sq Km)	*% Geographic area*	*Area under tree cover (Sq Km)*	*% Geographic area*	*Total area under forest & tree cover (%)*
Delhi	195.4	13.18	129	8.73	21.91
Haryana	1602	3.62	1563	3.54	7.16
Punjab	1849	3.67	1592	3.16	6.83
Uttar Pradesh	14,806	6.15	7342	3.05	9.2
Total India	712,249	21.67	95,027	2.89	24.56

Source FSI (2019)

A national-level scenario is modeled to estimate the total investment requirement for creating a carbon sink of 2.5 Billion tons. The total carbon stock per hectare is estimated at ~ 100 tonnes and hence, total land required for afforestation for 2.5 billion tons of carbon sink is ~ 25.5 million hectares (FSI, 2017). The investment required is ~ $600 per hectare National Mission for a Green India (2011). The total investment is allocated to forestry and agriculture sector at national level.

9.2.3 *Emission Reduction from Transport by Substituting Petrol/Diesel Vehicles with Electric Vehicles*

India imports the majority of the oil that is used, primarily, as fuel in the transportation sector and hence, there are major economic implications of any reduction in oil consumption due to switching away from internal combustion engines (ICE) to electric vehicles (EVs). Under the Graded Response Action Plan, if $PM_{2.5}$ concentrations are over 300 μg/m^3 or PM_{10} is over 500 μg/m^3 for more than 48 h, then diesel trucks carrying freight (except essential commodities) are banned from entering the NCT, and an odd–even scheme for private vehicle use is implemented.

As transportation is a year-round activity, band-aid measures such as odd–even schemes will need to be implemented and enforced numerous times throughout the year causing widespread disruption in daily life. Consequently, it is crucial for policymakers to focus on policies that lead to structural shifts. For example, a sustained shift to non-motorized transportation (e.g., walking and cycling) and mass transit (e.g., buses and trains) have been shown to significantly reduce the use of ICEs. The construction and operation of the infrastructure to support these policies—e.g., pedestrian plazas, dedicated bicycle paths, bus rapid transit, metros, etc.—will also result in new employment opportunities while the manufacturing of equipment such as bicycles, buses, and trains can offset the reduction in jobs in the car manufacturing sector. Good quality data is not available for modeling these policies in the NCT yet although a few researchers have initiated efforts. Consequently, in this chapter, we focus on one structural policy—i.e., substituting ICEs with EVs—that can be relatively easily analyzed.

Several states—including the four states in the NCT airshed—have formulated state-level EV policies (Government of Punjab, 2019; Government of Uttar Pradesh, 2018; Government of NCT of Delhi, 2020; and Tornekar, 2020). In addition, the Indian government has launched its Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles schemes that encourages, and in some segments mandates, the adoption of electric vehicles (EV), with a goal of reaching 30% EV penetration by 2030 (Sahay, 2019). Further, NITI Aayog has proposed setting up electric battery manufacturing factories for a targeted capacity of 50 GWh per year over the next ten years at projected cost of USD 5 billion (Pimpalkare, 2020).

In this scenario, we model a conservative switch of 10% from oil to electricity in the land transportation sector by 2030 in all four NCR states. The energy switch is calibrated to account for added energy efficiency offered by efficient electric vehicles (half the energy consumption). The increase in demand of electricity from the land transport sector will lead to greater investment in the power sector which is endogenously captured through the model. This switch is also augmented by modeling an estimated investment of $5 Billion in battery manufacturing (through the electrical equipment sector) by 2030 at the national level. We do not model additional automobile manufacturing as we assume that existing manufacturing facilities for oil-based vehicles will be re-configured to manufacture EVs.

For this scenario, we expect the impact to be modestly positive across most economic indicators due to the decrease in oil imports, combined with increases in domestic investments (e.g., battery manufacturing) and the subsequent new economic activity.

9.2.4 Reducing Biomass Burning by Crop Residue Utilization

Agriculture is one of the key economic sectors in India and especially important one for three of the states in the NCT airshed—Punjab, Haryana, and UP. It is also one of the most politically sensitive topics in India. In September 2020, the Indian government passed new legislation that reforms major elements of the sector which has led to substantial protests by farmers in many places but especially, in Punjab. In fact, for the last 50 days the farmer protests in Punjab have prevented movement of railways (both freight and passenger) because of which the negative economic impact on Punjab is estimated to be as high as USD 4.28 billion (Rs. 30,000 crores) (Sharma, 2020).

Within agriculture, paddy is considered one of the most important crops. Not only is rice consumed domestically as it is part of the staple diet, India is the largest exporter of rice in the world bringing in valuable foreign exchange (Chandresekhar & Ghosh, 2019). A large share of domestic purchase of rice is by the Indian government at a regulated price while the price achieved in international markets is dependent on the global supply–demand balance. Unsurprisingly, paddy farmers are extremely concerned with any policy that could raise their costs as they may not be able to pass on this incremental cost on to consumers through higher prices.

Paddy is usually harvested in October and within a short period of time—as short as a week—the field has to be prepared for planting the next crop. This short period of time is a consequence of a law that seeks to conserve groundwater and instead maximize use of rainwater because Punjab, as well as most of the Indian sub-continent, has seen rapid depletion of groundwater (Rodell et al., 2009). Overuse of groundwater that has to be pumped out has negative implications for the power sector as most of the electricity sold to the agriculture sector is significantly below the cost to serve it. A recent study reveals that though flat tariffs have low administrative costs and more equitable distributional outcomes, they do not provide incentives to farmers for water conservation (Sidhu et al., 2020). Further, the subsidy is offset by seeking direct financial support from state budgets and over-charging commercial/industrial consumers of electricity leading to adverse impacts in those sectors.

Today, the easiest and cheapest (practically, free!) way to prepare the field—i.e., getting rid of the rice stubble remaining in the ground post-harvest—is to burn it. Burning crop residue is a crime under Section 188 of the IPC and under the Air and Pollution Control Act of 1981. Yet the stubble burning has not stopped. The resultant smoke from these fields spreads across most of northern India during this period. Burning fields also degrades the fertility of soil by loss of nutrients and microbial cover and increases dependence on chemical fertilizers by farmers (Agricoop, 2014). It is crucial to note that there is minimal agricultural activity in the NCT due to urbanization and it is therefore no surprise that the Graded Response Action Plan does not include measures to reduce the burning of rice stubble, though Delhi's government has recently started pilots for facilitating use of organic decomposers in the NCT (*India Today*, 2020). While the focus of this chapter is on improving the air quality in the NCT, the adverse impacts of smoke from rice stubble burning and reduction in soil fertility adversely affect the rural population (including the paddy farmers) in Punjab, Haryana, and UP the same as the NCT population, if

Table 9.4 Total investment per year for happy seeder in Haryana, Punjab and Uttar Pradesh

State	*Total area under paddy cultivation (thousand Hectares)*	*Total area for Happy Seeders (thousand Hectares)*	*Total No of Happy Seeders*	*2011 USD million per year till 2030*
Haryana	1354	451	836	1.2 (84)
Punjab	2975	992	1836	2.6 (184)
Uttar Pradesh	5867	1956	3622	5.17 (362)

Note The values were provided in Rs. Million which was converted into USD million using th exchange rate 1 USD = 70 INR
Source MOSPI (2018), Author's estimate

not worse. In other words, these states have the same incentives to reduce rice stubble burning as does the NCT.

We model a scenario where instead of burning the rice stubble, one-third is removed using Happy Seeder technology, one-third is used as fuel for electricity generation, and one-third is used as input to cardboard manufacturing by 2030.[1] It is important to note that this is one policy scenario among many that could be modeled.

The Happy Seeder machine cuts and extracts rice stubble, plants wheat (i.e., the next crop), and spreads the extracted rice stubble over the newly sown area as mulch. The benefits of the machine continue to be debated as the use of these machines by farmers is not yet widespread. While some claim that the productivity increase is substantial, others have not been able to see any change because of the machine (Goyal, 2019).

We estimate total investment—equally divided over the next 10 years—on Happy seeders that will be sufficient for avoiding the burning of one-third of the rice crop residue generated annually in Punjab, Haryana, and Uttar Pradesh by 2030. The total area under paddy cultivation is presented in Table 9.4. The number of total happy seeders was estimated on the basis of 54 hectares per season (15–20 days use) and the prevailing

[1] Using rice stubble as fuel for electricity generation—if uncontrolled—will have emissions. We assume that these biomass-based electricity generation facilities are regulated and hence have installed the necessary air pollution control systems.

seeder cost of INR 1.5 lakh was used to do the estimation (Singh et al., 2017).

The use of happy seeders also leads to increases in productivity by reducing the need for irrigation as the wheat seeds are sown deeper in the soil. Studies reveal that in a no drought normal crop season, total consumption of energy for wheat cultivation can reduce from 5770 MJ/hectare to 1000 MJ/hectare. This energy saving is converted into GWh of power saved per year toward irrigation gradually phasing in over 10 years in the scenario (Table 9.5).

Several successful models where biomass-based generators have taken the entire responsibility of collecting the crop residue from the farm to the power plant and provide cash to the farmers per ton of residue collected have been implemented in India (Sood, 2015). As described earlier, one-third of the crop residue is utilized for electricity generation where the farmer receives cash compensation of Rs. 800/ton (Singh et al., 2020). The total power generation potential is estimated on the basis of average use of 325 ton per day for a 12 MW plant with generation of 288 MWh per day (Rao, et al., 2013). The remaining one-third is sold as input to cardboard manufacturing, yielding a cash compensation of Rs. 1500/ton to the farmer. The cash transfers are modeled as an increase in income for rural households commensurate to the landholding patterns in each state. Increased incomes will lead to a relative increase in consumption expenditure and demand across economic sectors (Table 9.6).

The objective of this exercise is to demonstrate the value of the E3-India model in accurately assessing the comprehensive implications of

Table 9.5 Total energy saving for wheat crop due to happy seeder in Haryana, Punjab and Uttar Pradesh

State	*Total area under wheat cultivation (thousand Hectares)*	*Total MJ of Energy saved/year*	*KWh*	*GWh/year till 2030*
Haryana	2,576	3,597,813,333	971,409,600	97.1
Punjab	3,499	4,886,936,667	1,319,472,900	131.9
Uttar Pradesh	9,645	13,470,850,000	3,637,129,500	363.7

Source MOSPI (2018), Author's Estimates

Table 9.6 Estimations for total biomass based generation potential in Haryana, Punjab and Uttar Pradesh

State	**Total Crop Residue estimated (M Ton) through IPCCC default coefficients*	*Total Generation Potential Per year (GW)*	*Total Cash transfer for biomass @ INR 800/ton (Million USD)*	*Total cash transfer for cardboard making @ INR 1500/ton (Million USD)*
Punjab	2.28	0.29	1217.8	2283
Haryana	4.43	0.57	2364.4	4433
Uttar Pradesh	7.46	0.95	3978.7	7460

Source Singh, R. et. al. (2020) and Authors' estimates

policies targeted to individual sectors such as agriculture that are extensively linked in myriad ways with the broader economy. For example, experts suggest that excessive paddy farming can be discouraged through changes to minimum support prices set by the Indian government and also through capping procurement by the government. Instead, the government could incentivize farmers to grow less water-intensive crops that would address multiple issues such as less water use (and hence, electricity use for water pumping), lower pollution (i.e., no need for stubble burning), and better public health (through lower consumption of carbohydrates). The complexity of these comprehensive policies is beyond the scope of the analysis in this chapter.

9.2.5 Power Sector Interventions for Reducing Industrial Emissions

Electricity is one of the key inputs to most economic activities as well as directly improving the quality of life. It is important to note that propagation of changes through the economy that result from power sector-specific policies such as those modeled here in the Indian context is likely to be far more complex in the real world due to inherent distortions such as low prices charged to poor consumers that are offset by subventions from state government budgets (which impact other state government expenditures) and cross-subsidies from wealthy consumers who are charged high electricity prices. The prices paid by electricity consumers do not reflect the marginal cost of electricity but are set administratively by state electricity regulators. The existence of long-term power procurement arrangements between each electricity generator and distribution company further distorts the use of the cheapest marginal cost generation (i.e., out of merit-order dispatch). These two distortions together contribute to major financial losses faced by distribution companies that in turn get transmitted to electricity generators.

As both distribution companies and generators borrow from the banks (most of them owned by the central government), the losses on the banks' balance sheets eventually get addressed by central government's re-capitalization initiatives which would impact overall central government expenditures. For the analysis presented here, we do not incorporate these financial distortions but focus on two key air pollution control alternatives for the power sector.

Today, one of the major sources of electricity in India is thermal power plants (TPPs) that burn coal as fuel. The four states in the airshed account for about 19% (~ 43.8 GW) of total installed thermal capacity in India (CEA, 2020). Consequently, TPPs are a major source of air pollution. We model two scenarios through which air pollution from TPPs can be reduced within the NCT.

9.2.5.1 Installation of Air Pollution Control Equipment

Since 2015, TPPs have been subject to policies that limit their emissions, which increase the cost of the electricity they generate. However, despite ongoing efforts, very few TPPs have installed air pollution control equipment and recent reports suggest that it is unlikely that they will install them in the near term (Vishnoi, 2020).

Bharat Heavy Electricals Limited was contracted for the installation of a Flue Gas Desulfurization system at NTPC's 2 × 490 MW Dadri plant for removing sulfur dioxide at a cost of Rs 5,600 million, indicating that the capital cost is USD 81,728/MW (Rs 5.7 million/MW) (PowerLine, 2018). The impact of this additional expenditure by TPPs on the average generation cost is approximately, USD 0.002/kWh (INR 0.19/kWh). We assume these two representative values as inputs for our analysis. The scenario is modeled as increased investment by the power sector in electrical equipment, along with a tax on thermal power generation to pay for the equipment. The cost of this tax is passed on to consumers across India.

As mentioned in earlier scenarios, the objective of this exercise is to demonstrate the use of E3-India in providing insights about the impacts of sector-specific policies. Consequently, we use point estimates for the control of a single pollutant—i.e., SO_2—in this analysis. Additional analysis is necessary for assessing scenarios where alternative SO_2 reduction strategies are deployed (e.g., switching from high-sulfur coal to low-sulfur coal). Similarly, analysis can be done to assess the implications of controlling other major pollutants such as NO_X, PM (1.0, 2.5, and 10.0), mercury, ash, and others. Analysis is also possible for reducing the use of water in Indian TPPs through the deployment of water recirculation systems.

There are two ways in which this investment is propagated through the model—a investment in air pollution control equipment leads to additional economic activity and by an increase in the cost of electricity leads to both lower economic activity and reduction in coal generation and capacity for the airshed. Generation levels are estimated by E3-India's Future Technology Transition (FTT) module (Mercure, 2012; Mercure et al., 2014). The net effect of these impacts on each state varies because of the TPP capacity located in each state and their consumption of TPP-sourced electricity.

9.2.5.2 Greater Use of Renewable Energy in the NCT Airshed

New renewable energy (RE) generation technologies such as solar and wind are now cheaper than TPPs (Bharvirkar et al., 2019). Consequently, it is expected that far fewer—if any—new TPPs are likely to be built in the future than what was expected a few years ago. More use of RE instead of TPPs reduces air pollution from electricity generation, while also reducing the overall cost of electricity. Further, the advent of a wholesale power market also creates opportunities for managing air quality through cost-effective planning to reduce coal-based generation during poor air quality seasons (Athawale & Bharvirkar, 2019).

In order to model this scenario, the outputs from TERI-ETC's recently published "Renewable power pathways: Modeling the integration of wind and solar in India by 2030" were taken as inputs to E3-India (Spencer et al., 2020). The ETC's Baseline Capacities Scenario (BCS) reflects the assumptions of the 2018 National Electricity Plan, developed by the Central Electricity Authority (CEA, 2018). The High Renewable Energy Scenario (HRES) has a higher level of renewable energy production capacity, reflecting the assumptions of the CEA's Optimal Mix study (CEA, 2019). The details of scenario inputs are detailed in the Appendix (Sect. 9.5). As the electricity demand is expected to grow and, consequently, new electricity generation capacity is required—whether TPP or

RE—the overall economic impact is expected to be positive due to new economic activity.

Assessing the impact of policies individually provides insights on their relative strengths and weaknesses. In reality, all the policies modeled in this chapter are at least at an advanced stage of discussion if not being partially implemented. Consequently, there is the potential for interactions among these policies. These interactions will need to be assessed to ensure that they are reinforcing each other—i.e., in terms of reducing emissions and improving various other metrics such as GDP, employment, and others—instead of offsetting the gains from each other. We present two integrated scenarios in addition to the individual policy scenarios described earlier: 1. high share of RE combined with the EVs and 2. all policies implemented.

A potential downside of growth of EVs is that incremental electricity demand is met by the dominant source of electricity—i.e., coal generation. In other words, tailpipe emissions are substituted by smokestack emissions (Knobloch et al., 2020). Considering that substantial thermal capacity is homed in the airshed, it is crucial to ensure that TPP emissions are reduced simultaneously with the increase in use of EVs. The "All Policies" scenario is self-explanatory and will allow us to evaluate the simultaneous impacts of all the interventions together, along with probable interactions as we expect in a real-life scenario.

9.3 Results and Discussion

All the scenarios described in Sect. 9.4 are summarized in Table 9.7. In order to simplify the figures, the nomenclature shown in Table 9.7 is used.

The analysis presented in this chapter is focused on reducing air pollution from four sectors of the Indian economy. The ideal metric for measuring the efficacy of the various policies that are used to reduce air pollution would require accurate estimates of the amount of pollution from each source. Unfortunately, three sectors—agriculture, transportation, and construction—are diffused in nature and no accurate estimates exist for the amount of pollution they cause. The power sector—specifically, TPPs—is relatively easier to monitor from an emissions perspective.

The policies analyzed in this chapter will reduce pollution from all four sectors—i.e., rice stubble burning is eliminated, electric vehicles substitute petrol/diesel vehicles, construction activity is banned, green cover is increased, and TPPs are either replaced by RE or install air pollution

Table 9.7 Summary of source-wise assessment scenarios

Name	*Short description*
Construction	Ban on construction for 2.4 months each year in NCT
Afforestation	Increased investment in expanding green cover nationwide
Transportation	Substitution of ICEs with EVs in the NCT
Agriculture	No more burning of rice stubble; Instead, use of Happy Seeder, biomass-based electricity generation, and cardboard manufacturing from rice stubble
High RE	Increase in renewables nationwide
Emission Control	Equipment added to coal power plants to reduce emissions nationwide
High RE and Transportation	A combination of more renewables and a shift to EVs
All	A combination of all the different policies

control equipment. The primary focus of the analysis is to understand the impacts of airshed management on underlying economic linkages in each state. Gaps in the available data mean that it is not possible to assess impacts on the level of pollution.

The metrics presented in this section include Gross Domestic Product (GDP), Consumption, Employment, Lowest Rural Income Quintile, Coal Generation, and CO_2 emissions. GDP measures the final value of the goods and services produced in one year in the specific state and/or country. Consumption refers to consumer spending and employment refers to the number of jobs created. Population is categorized in 24 income classification, 12 each for rural and urban citizens. The results presented in this section refer to the lowest rural income category as a way of assessing the equity impacts of policies. Coal generation refers to the amount of electricity generated by TPPs in one year while CO_2 emissions refer to economy-wide annual emissions. Several other outputs—e.g., sectoral employment—are also available in E3-India that can, potentially, provide more nuanced insights. In the interest of brevity, we present results across only these six metrics.

For the High RE, Transportation, integrated High RE and Transportation, and afforestation scenarios, we observe an increase in GDP in all four states in the NCT airshed, as well as at national level. However, in the case of the Emission Control, Agriculture, and Construction scenarios we see a significant contraction of GDP across all four states and at the national level. Not surprisingly, in the All scenario—where, all policies are modeled simultaneously—the distribution of GDP growth and contraction is uneven across the four states because of the interactions. This is precisely why a modeling platform such as E3-India is invaluable for understanding both aggregate (e.g., national/regional) and disaggregated (i.e., state-level) implications of policies (Fig. 9.3).

For the High RE scenario, the drivers for GDP expansion are primarily two-fold: 1. new economic activity resulting from new investments (i.e., new RE power plants) and 2. expansion of existing economic activity resulting from a lower cost of electricity (because RE-sourced electricity is less expensive than TPP-sourced electricity). Similarly, for the Transportation scenario, new investments in battery manufacturing and allied sectors such as automobile manufacturing result in new economic activity while the overall increase in energy efficiency because of the switch from internal combustion engine to electric motors yields higher economic productivity and, hence, growth. The High RE and Transportation scenario unsurprisingly reinforces these growth trends resulting in an even larger expansion of the GDP. The afforestation scenario is modeled as increase in investment in forestry and agriculture sectors leading to concomitant increase in GDP.

For the Emissions Control and Agriculture scenarios, while there is new investment (i.e., installation of FGDs, purchase of Happy Seeders,

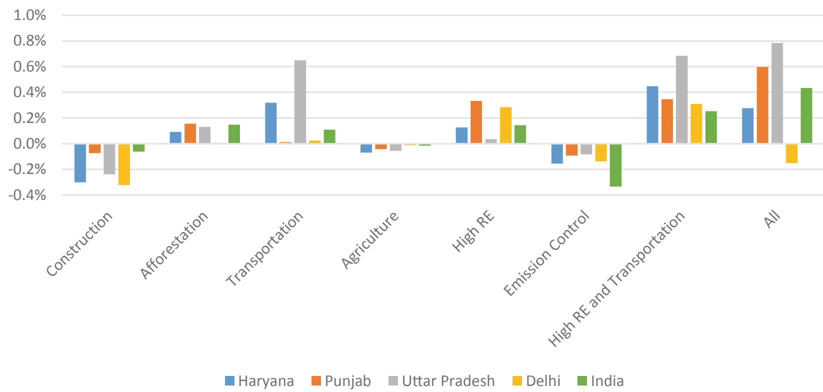

Fig. 9.3 Percentage change in GDP in 2030 (*Source* Results from the model)

and cardboard manufacturing), the aggregate expansion of GDP induced by this is offset by the increase in the cost of electricity. Installation of emission control equipment increases the cost of electricity for consumers, leading to a reduction in output and consumption for the economy, causing a reduction in GDP. In the case of the agriculture sector, the combined economic impacts of increased biomass-based generation (which is inflationary in the state power mix) and a reduction in power consumption due to lower need for irrigation (from happy seeder use) offsets the impacts associated with cash transfers to farmers. Electricity is a crucial input to most economic activity while paddy is a major component of food consumed by most citizens. Individual analysis of any sector (e.g., power, agriculture, etc.) would not be able to assess such offsetting impacts and hence, the overall implications for the economy. The construction sector output contributes only 2–6% of total output of individual states by value but engages close to 8–11% of labor in the NCT airshed region. E3-India captures this as a contraction in GDP across the states.

From the perspective of employment, a politically sensitive issue, the negative impact observed under the Construction scenario is of the highest concern—see Fig. 9.4. Construction is one of the major employers in the Indian economy and especially, in an overwhelmingly urban state such as Delhi. A blunt policy approach such as an outright

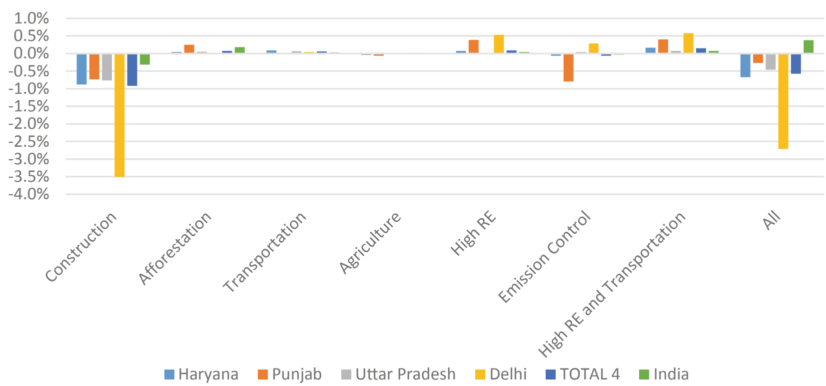

Fig. 9.4 Percentage change in employment in 2030 (*Source* Results from the model)

ban on it, even for a short period of time, leads to a substantial increase in unemployment, especially, in urban states such as Delhi. The striking aspect of these results is the relative size of the change. Unlike the changes seen in GDP and investment, the impact on employment is far larger (in percentage terms) and reiterates the labor-intensive nature of the Indian economy in general and specifically, a sector such as Construction. We also find that only 15–20% of the jobs lost from the construction sector get reallocated to other labor-intensive sectors like food and beverages, textiles and leather, and motor vehicles. Instead of simply shutting down construction activity, alternative measures for reducing dust pollution from this activity must be explored. Further, a larger diversification of the labor force in other activities like afforestation during the sensitive period could lead to better economic outcomes even under the COVID constraints (Pollitt, 2020). If bans on construction are designed to be episodic in nature lasting a few days when the air quality is especially bad then income support schemes for the labor employed in this sector could be considered.

Under the High RE and Transportation scenarios, there is a modest increase in employment resulting from new investments and lower-cost electricity. The largest increases in employment in the High RE scenario are found in electric supply, electronics and electrical equipment sectors, followed by a large positive indirect impact on construction activity and other business services. The Transportation scenario reveals an increase in employment in other vehicle manufacturing, along with electronics and electrical manufacturing. The scenario also sees a large positive impact on employment in the construction sector. The impact on employment is somewhat mixed under the Emissions Control scenario because of the offsetting policies—i.e., new investment but higher-cost electricity—and varies substantially across the four states. Punjab sees a major decrease in employment, driven largely by the construction, agriculture, and hotels and catering sectors, while Delhi sees a large increase in jobs in both sectors like construction, textiles, and food and beverages along with high-tech sectors like electrical equipment and electronics. The Agriculture scenario suggests minimal negative impact on employment, primarily due to constrained economic activity in the power sector.

Combined together—the negative impact of the Construction scenario overwhelms the positive impacts of other policies. Consequently, from a political economy perspective, it is crucial to develop alternative strategies to limit pollution from the construction sector, even if it results in a somewhat higher cost of construction activity. Further, as a long-term policy, strategic diversification of the labor force to other environmentally benign but skill-intensive sectors for seasonal employment creation will be vital to manage the adverse impacts of seasonal reduction in construction activity. A ban on construction activity under GRAP is more of a kneejerk reaction to environmental consequences and does not provide a permanent solution to the problem. The development of intrinsic flexibility to switch economic activities proactively for better management of the NCT airshed is critical.

Changes in employment also have an impact on consumer spending. The trends in consumer spending—see Fig. 9.6—confirm the discussion presented in the context of the impacts on economic growth and employment. High unemployment in the Construction scenario—especially, among the workers who are already in the lower income strata—results in a relatively high decrease in consumer spending. It is important to note that most of the consumption spending of poor citizens is not on discretionary items but on items necessary for survival (e.g., food, medicines, etc.). Consequently, the reduced spending is likely to have further adverse impacts on their health and overall quality of life.

The Emission Control scenario also shows a negative impact on consumer spending similar in size as under the Construction scenario even though there is no major impact on employment. The primary driver for this is the increase in electricity price which reduces consumer spending on other things as electricity is one of the relatively inelastic commodities that consumers purchase. It is no surprise that Discoms and electricity regulators in addition to state governments absolutely abhor raising electricity prices. Historically, instead of raising electricity prices, Discoms have accrued financial losses that periodically have to be addressed through schemes such as UDAY. In contrast to the Emissions Control scenario, consumer spending increases under the High RE and Transportation scenarios because of increase in employment. Under the High RE scenario, the reduction in electricity costs also creates more opportunity for increased consumer spending. Under the Agriculture scenario, there is modest reduction in consumer spending driven by reduced employment, increase in input costs (investment in Happy Seeders), and increase in electricity costs (biomass-based generation) that is not offset by the income growth. In aggregate, the negative impact seen under the Construction, Emission Control, and Agriculture scenarios easily overwhelms the relatively small positive impacts under the High RE and Transportation scenarios (Fig. 9.5).

Implications for the poorest citizens of India—i.e., living in rural areas with incomes in the lowest quintile (0–5 percentile)—are crucial for understanding the overall equity implications of policies. Income impacts can be disproportionate across various income quintiles because of both consumption patterns and also the ability to survive a potentially negative impact. Both the Emissions Control and Construction scenarios result in the biggest reduction in rural incomes in the lowest quintile, across all four states and at the national level. The increase in the cost of electricity disproportionately impacts poorer households due to prevalent energy poverty conditions (Khandker et al., 2010). Poorer households suffer along with everyone else when there are reductions in GDP and employment across the economy. In contrast, the High RE and Transportation scenarios yield a relatively small increase in the income of the poorest citizens because they either reduce the cost of electricity to low-income households or provide a general boost to the wider economy that raises incomes in all household groups.

The large positive impact on the income of the poorest citizens of UP under the Agricultural scenario is a result of the way this scenario

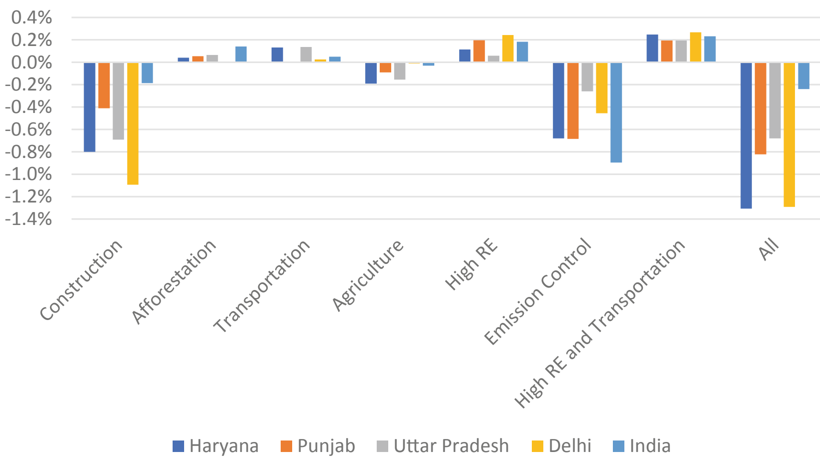

Fig. 9.5 Percentage change in consumer spending in 2030 (*Source* Results from the model)

was modeled in the form of cash transfer to farmers toward crop residue collection on the basis of land ownership patterns. In the case of UP, more than 62% of landholding is by small farmers. Therefore, a relatively (as compared with farmers in Punjab and Haryana) greater share of cash benefits was received by small (i.e., low income) farmers. The results suggest that distributive impacts of cash transfers for crop residue utilization can result in larger income benefits to small (and poor) farmers who are most likely to resort to burning rice stubble (Fig. 9.6).

One of the direct impacts of the policies analyzed in this chapter is likely to manifest itself in the power sector—due to a change in cost of electricity and/or demand—and especially, in the major source of electricity, i.e., TPPs. In the following figure, coal generation decreases substantially in all the scenarios except Emission Control and Transportation. The increase observed for the Transportation scenario is simply due to the increase in demand for electricity to charge electric vehicles (direct impact) and new battery manufacturing (direct and indirect). In the case of the Emission Control scenario, the increase in coal generation is because of the increase in electricity demand to meet the large increase in investments in new equipment (i.e., installation of emission control systems on TPPs) that result in new economic activity. Some of this increase in electricity demand is dampened by the higher cost of electricity. However, the net impact is on increased TPP generation.

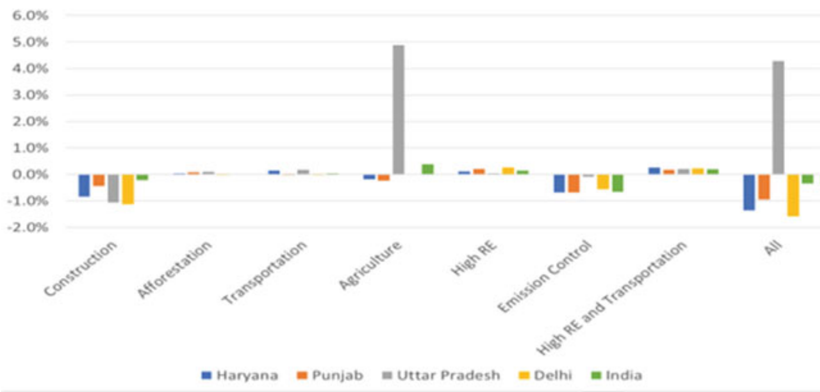

Fig. 9.6 Percentage change in rural income (lowest percentile) in 2030 (*Source* Results from the model)

Both the High RE and Agriculture scenarios yield a significant reduction in coal generation. The High RE scenario has a straightforward explanation—i.e., the objective of the policy is to substitute TPP-sourced electricity by RE. In case of the Agriculture scenario, some of the coal generation is replaced by biomass generation and also results in a higher cost of electricity that further depresses electricity demand. The contraction in GDP suggests lower demand for electricity with no major new investments that can offset this reduction through increased activity in the rest of the economy. The cumulative impact of these drivers results in a significant reduction in coal generation under the Agriculture scenario. Taken together, under the All scenario, a substantial reduction in coal generation is observed across all four states with Haryana and UP leading the way followed closely by Punjab and a relatively small decrease in Delhi. The major decrease results from the High RE and Agriculture policies and a minor decrease because of the periodic ban on construction activity (Fig. 9.7).

Lastly, we present the overall impacts of policies on CO_2 emission across the economy. Except for the Transportation scenario, in case of all other scenarios we find that CO_2 emissions decrease. The largest decrease is observed under the Agriculture and High RE scenarios followed by modest decreases under the Construction and Emission Control

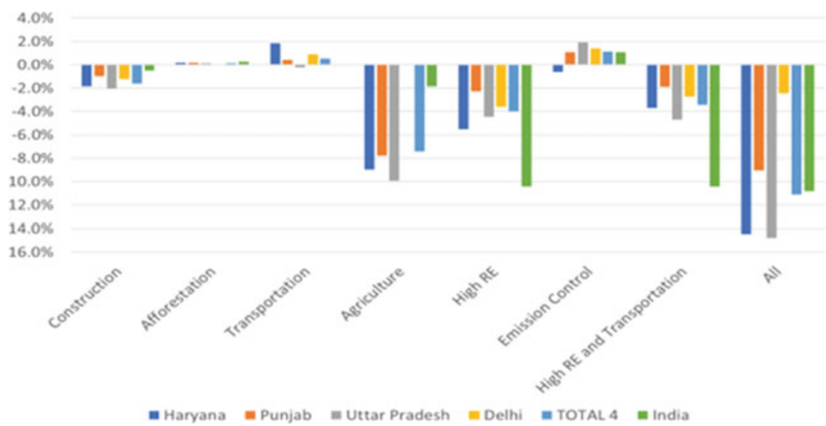

Fig. 9.7 Percentage change in coal generation in 2030 (*Source* Results from the model)

scenarios. The increase under the Transportation scenario is driven by the increase in coal generation even though some of it is offset by fewer ICEs. A combination of High RE and Transportation policies ensures that even there is no increase in CO_2 emissions across the economy (Fig. 9.8).

Poor air quality—especially in the NCT—has been a chronic and vexing problem. While various policies continue to get discussed and sometimes implemented in a stop-gap manner, sustained progress in improving air quality has been elusive. Even in 2020, a year in which the Indian economy was practically brought to a standstill for six weeks because of the raging global pandemic, the air quality in the NCT was in the Severe category during the entire first week of November.

The sources of air pollution have been identified, even though high-quality data and analysis is not yet available for accurate apportionment. The strategies for reducing air pollution from these well-known sources are technologically viable and institutionally feasible while being cost-effective when assessed in the context of the overall health benefits from improved air quality. Yet, there is resistance to implement these strategies immediately and at the scale needed.

Economic impacts—both direct and indirect—underpin the overall political economy that makes decisions not only about the design of policy but also its implementation and enforcement. Direct financial impacts of policies to individual stakeholders are relatively well understood. However, broader economic impacts are not yet part of the policy discourse.

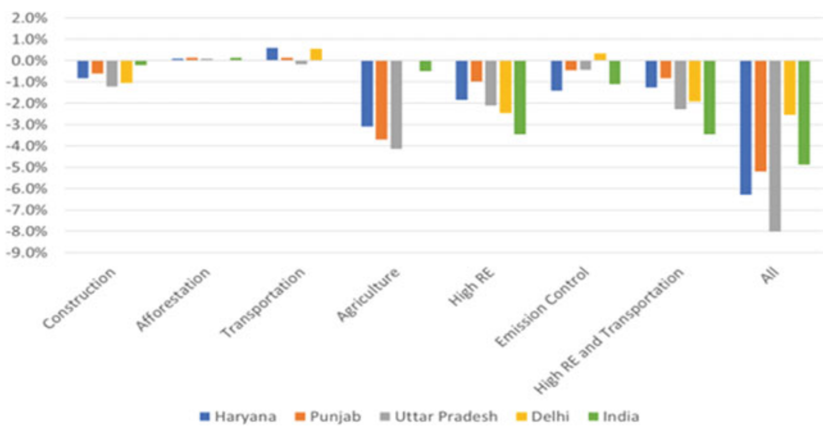

Fig. 9.8 Percentage change in CO_2 emissions in 2030 (*Source* Results from the model)

9.4 Conclusion

The key takeaways from the analysis are presented in this section. In this chapter, through stylized policy scenarios, we have attempted to estimate the broader impacts for the four major states relevant in the NCT airshed. We present results for both individual policies and integrated policies where more than one policy are simultaneously implemented. The objective of this analysis is not precision in terms of the policy design but a demonstration of the E3-India platform to illuminate how the policy propagates through the state and national-level economies.

A periodic ban on construction activity in the four states results in a massive negative economic shock to their economies resulting in GDP contraction, reduced investment, decrease in employment, and a substantial loss in income for the poorest citizens. Consequently, this blunt policy instrument should be considered as a last resort and substantial efforts toward developing alternative strategies to reduce pollution from this sector should be undertaken immediately.

A nationwide shift toward a High RE future for the Indian power sector results in the expansion of GDP, increased investments, higher employment, increased consumer spending, and a larger income for the poorest 70% of the rural citizens of India. These results—at varying levels—are observed in all four states in the NCT airshed. From an air pollution perspective, this scenario also yields the highest reduction in coal generation (and hence, emissions from it) as compared with other policies. The additional benefit of this policy is the decrease in CO_2 emissions which is a major global concern from a climate change perspective.

Installing emission control equipment on TPPs results in significant new investments in the four states which are politically attractive. However, the net impact of this policy is negative with an overall contraction in GDP, decrease in employment, significant drop in consumer spending, and reduction in income of the poorest citizens. Both the generation and capacity of TPPs increase under this scenario. Yet, there is an overall decrease in CO_2 emissions that are the primary driver for global climate change. As there are no easy and cheap ways to reducing CO_2 emissions from TPPs yet, the only remaining approach is to minimize the use of TPPs. In many parts of the world TPPs are—in fact—being phased out in favor of less carbon-intensive technologies (e.g., gas) and carbon-free technologies (e.g., RE, batteries, etc.).

Substituting internal combustion engines to electric motors yields a significant expansion in GDP for UP and Haryana driven mostly by the new investments in battery manufacturing. However, impacts measured in terms of employment, income, consumer spending, and coal generation are minimal at best.

Instead of simply burning rice stubble, using a portfolio of strategies consisting in equal parts of Happy Seeders (to mechanically remove stubble and plant wheat), utilizing stubble for electricity generation, and cardboard manufacturing from stubble result in a significant reduction in coal generation. The impact on GDP, investment, employment, and rural incomes are minimal relative to other policies.

Assuming that all these policies are implemented simultaneously results in a wide range of impacts distributed among the four states. Delhi sees the largest GDP contraction followed by Haryana, while UP sees the largest GDP expansion followed by Punjab. All four states see a significant increase in investments with Haryana and Punjab benefiting by more than double that of UP and Delhi. A reduction in employment is observed for all four states but the primary driver for this result is the policy banning construction activity periodically. There is a dramatic reduction in coal generation in all four states with the smallest amount observed for Delhi. Incomes—especially, for the poorest rural citizens—drop for all states except UP where it increases by almost 4%.

Various permutations and combinations of policies can be easily modeled using the methodology presented in this chapter which can provide additional insights. One such variation that we modeled included the combination of the High RE and Transportation scenarios. Across all four states, GDP expands, investment increases, employment grows, coal generation reduces, and income of poorest rural citizens rises. In other words, these two policies are mutually reinforcing.

As with all modeling exercises, it is important to be aware of the limitations of the analysis. The main limitation here relates to the data issues noted above and the difficulties in linking air pollution to different sources. This means that the benefits to health of reducing air pollution are not assessed in our analysis. There are also places in the scenarios where the use of more detailed input assumptions (e.g., on the costs of measures in the Agriculture scenario) could improve the accuracy of results. Readers are urged to view this analysis as a starting point in the process of evidence-based policymaking pertaining to air quality.

Appendix

See Table 9.8.

Table 9.8 Capacity addition under baseline and High renewable energy scenario (in GW)

	National			*Haryana*			*Punjab*			*Uttar Pradesh*			*Delhi*		
Capacity Installed Year	*Base year 2019*	*Baseline 2030*	*HRES 2030*	*Base year 2019*	*Baseline 2030*	*HRES 2030*	*Base year 2019*	*Baseline 2030*	*HRES 2030*	*Base Year 2019*	*Baseline 2030*	*HRES 2030*	*Base Year 2019*	*Baseline 2030*	*HRES 2030*
Coal	185.08	248.84	262.98	8.64	12.35	13.77	8.56	15.09	17.35	14.99	23.20	26.16	5.57	11.19	12.73
Onshore	37.94	126.82	164.98	0.89	0.57	1.13	0.79	0.57	1.13	0.00	0.00	0.00	0.00	0.57	1.13
Solar PV	27.44	175.47	224.10	0.53	2.48	4.70	1.93	2.08	3.19	0.99	10.02	14.52	0.20	0.83	2.40

Source Authors' Calculation

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CHAPTER 10

Liquidity Infusion: An Assessment of Atmanirbhar Package Using E3-India Model

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10.1 Introduction

India's growth paradigm has changed in recent times, shifting from the sufficiency in looking at only the National level GDP to the inclusive growth targeting the regional development. In line with the above

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thought, the countries have rapidly started to focus on the policy packages simulating the financial inclusion across the population to reduce the existing socio-economic inequalities. Financial inclusion here refers to the process of ensuring access to financial services, and timely and adequate credit particularly for the vulnerable groups and low-income groups at an affordable cost. The importance of expanding the scope of financial services lie with the capability of this variable in generating multiplier effect on the economic output, reducing poverty and income inequality, and in promoting gender equality and empowerment of women and backward classes of the society.

The Government of India has made several attempts for expansion of financial services to the population. About 80% of the Indian adults have bank accounts in 2017 which has increased from 53% in 2014 (World Bank, 2017). The progress has been attributed to the various programmes undertaken by the Government of India over the years for expansion of credit to various sectors. It has launched its flagship programme Pradhan Mantri Jan Dhan Yojana (PMJDY) in August 2014 to provide universal banking services for every unbanked household, based on the guiding principles of 'banking the unbanked', 'securing the unsecured', 'funding the unfunded' and serving unserved and underserved areas. The bank accounts under this programme were opened at Rs. 0 balance. It has utilised the technology penetration to expand the scope of credit provision by linking the Jan-Dhan account with mobile and Aadhaar. Further, the government launched National Mission for Financial Inclusion (NMFI) to create a universal social security system for all Indians, especially the poor and the underprivileged. The Mission has three components, namely, Jan Suraksha Schemes or Social Security Schemes pertaining to Insurance and Pension Sector for providing life & accident risk insurance and social security at a very affordable cost. The other components are Pradhan Mantri Suraksha Bima Yojana, Pradhan Mantri Jeevan Jyoti Yojana and Atal Pension Yojana, all expanding the scope of social security. Pradhan Mantri Vaya Vandana Yojana to protect elderly aged 60 years and above was started in 2018. To help the Micro, Small and Medium Enterprises (MSME), initiatives like Stand Up and Pradhan Mantri Mudra Yojana (PMMY) were launched. The target was to sustain the expansion in the flow of credit to the non-corporate small business sector for which loans up to Rs. 10 lakhs without collateral were extended to borrowers under PMMY (Ministry of Finance, 2020). Besides the Government of India and the Reserve Bank of India have undertaken various initiatives for financial penetration. It has launched a bank-led model of financial inclusion through the issuance of differentiated banking licenses (small finance banks and payments banks), the launch of Indian Post Payments Bank in September 2018, priority sector lending to target credit delivery in important but underserved sectors. The objective was to help bridge the gap in last mile connectivity and affordable and accessible credit through institutions like Regional Rural Banks, NABARD etc. (RBI, 2020).

However, certain critical gaps remain as impediments for financial inclusion. Some of these are inadequate infrastructure (in parts of the rural hinterland, far-flung areas in the Himalayan and north-eastern region), poor telecommunication and internet connectivity in the rural hinterland, socio-cultural barriers, and lack of market players in payment product space. Besides the above factors impeding the access, the rising Non-Performing Assets in Public sector Banks, collapsing of major Non-Banking Financial Institutions (NBFCs) and Cooperative Banks like that of Maharashtra Urban Cooperative in recent years, create further problems. These are some of the financing agencies which help in providing loans to the lower-income groups, farmers, MSMEs, Micro Finance Institutions and play a crucial role in the development of social infrastructure. A closer look at the data reveals that 48% of those who have an account in a financial institution have made no withdrawal or deposit in the past one year, signalling that the services are yet to reach the masses. Among those who still have no account, 23% report that it is primarily because of lack of financial institution at a reasonable distance and 27% reveal that it is because the financial services are too expensive for their pockets. This highlights the deficiency still present in providing last-mile connectivity of the banking services at an affordable rate. The primary factors for the above is the lack of infrastructure, financial education among the masses and the inherent structure of the Indian Economy. India has about 21.9% of its population below poverty line group (RBI, 2018) and bottom 50% of the population holds around 14% of the national income in India in 2015 (World Inequality Database, 2020). Besides this, more than 80% of its population is engaged in the Informal sector (Government of India, 2019–20) primarily comprising of Agriculture and allied activities and Micro, Small and Medium Enterprises (MSME). These sectors rely heavily on the informal sources of credit due to their inaccessibility to credit breeding from lack of infrastructure and bank's reluctance to lend to these sectors. Only 5% of the population have borrowed to start, operate, or expand the business or a farm which has reduced from 9% in 2014 while, 30% still rely on borrowing from friends or family (World Bank, 2017). This figure might be larger if other sources of informal credit are considered. Besides access to credit, the other factor that has been influencing the financial services is the slowdown witnessed for the past few years, attributable to both structural and cyclical factors in play.

The growth rate for the past year has been fluctuating around 4.5% to 5%, with Agriculture and MSMEs growing at nearly 2% growth rate (Government of India, 2019–20). The slowdown has been resultant of both supply and demand factors in almost all the sectors of the economy. The growing Non-Performing Assets (NPA) in the banking sectors, liquidity crunch in Non-Banking Financial Corporations (NBFCs) which are a primary lender to the priority sector and infrastructure are major contributors to this slowdown. This has been aggravated by the COVID-19 pandemic which has struck the world in 2020, dismantling both National level and sectoral economic growth. The pandemic has highlighted the already existent cracks in the social security and health sectors. The impact of the pandemic has been felt by almost the entire population, but at different rates and intensity depending upon their existing economic conditions and vulnerability. The migrant labourers, below poverty line group, lower- and middle-income sections engaged in MSMEs, Agriculture and allied activities and daily wagers are among the worst affected. The small sectors have choked on the unavailability of working capital resulting in shutdowns and large-scale unemployment. The large infrastructure projects have been stalled including the power sector due to financial constraints, lack of raw materials and supply-led inflationary prices of the inputs. The world economy is at a standstill which has reduced the imports of major raw materials that go into the industries, the exports have fallen and at the same time, the domestic demand has reduced due to income contraction of people. This has led to interstate migration, increasing the need for government assistance and heavy burden on the programmes like MNREGA. This has posed challenges to the Indian government as to how to maintain the sustainability of its population and provide them with social and income support in different ways. The current pandemic has affected the global economy in the worst possible manner since the great depression of the 1930s. Some of the sectors that have been directly hit are Transportation, Trade and Tourism, Manufacturing including consumer goods such as durables, Construction, Services and so on. The shock has constricted both the demand and the supply sides of the economy at sectoral and regional levels. The decline of economic activity and liquidity might crowd out investment in manufacturing, private investments and reduce the capacity of the economy to sustain the rising working force in the employment status. India has been facing jobless growth in recent years. In order to enjoy the demographic dividend in upcoming years, we will require more investment by the government for employment-generating sectors and inclusive growth. Unless financial aids are provided, the secondary sector might be unable to become the engine of growth and trade and burden of employment on Agriculture would reduce productivity. With population rise, it is important to focus on the Agriculture sector for food security. This requires easy credit availability for technological up-gradation. Many of the small and marginal farmers still depend on the informal sources, lack social support, rely on fluctuating rainfall for production due to unavailability of irrigation which creates a situation of vicious debt cycle. The COVID-19 pandemic has resulted in a decline of almost all the sectors which threatens to worsen the status of the debt trapped individuals.

To aid the economy in this crisis, the relief package was provided amounting to Rs. 20 lakh crores in the mid-May 2020, targeting the above sections of people by giving both immediate relief and medium-term reforms to target the structural issues. The package has been termed as 'Atmanirbhar', signalling the Government of India's attempt to make India a self-reliant economy by looking at the crisis as an opportunity. Most of this package has been injected into the system through credit provisions and changes in easy access to this credit which would help in tackling the crisis in the short-term and enhance the financial inclusion in the long run. The benefits of these measures under the Atmanirbhar Bharat policy package would also be dependent upon the existing status of financial inclusion in the economy which varies at the regional level. Complimenting the earlier policies, the target of Atmanirbhar Bharat policy is to meet the financing needs of different sectors to revive the economy.

The present chapter provides a comprehensive outlook on how the Atmanirbhar 1.0 package of credit and income support might affect the macroeconomic parameters in the future (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d). There have been additional packages announced in the month of October and November but the major structural reforms have been incorporated through Atmanirbhar Package 1.0

released in May. For the same purpose, sectors have been selected based on which scenario development has been formed along the lines of Atmanirbhar package. These are--Agriculture and Micro Small Medium Enterprises (MSME), Direct Income support policy, Reserve Bank of India (RBI) measures in form of monetary package and Investment in Physical and Social Infrastructure.

For this assessment, the E3-India model has been used. This is a macro-econometric simulation model to assess energy-environment-economy linkages for India using state-level data. E3 India is a dynamic multi-sector Input–Output and macro-econometric model with detailed regional components in three dimensions, namely Energy, Environment and Economy. The model has been calibrated for 32 Indian states and territories to provide state and region-specific results.[1] The impact of Atmanirbhar package will depend on the past factors of financial inclusion in the respective states, their existing economic status and the poverty figures. Thus, it is important to assess the impact of the package on the regional and sectoral level which is best provided with E3 India. This chapter analyses the possible effects of these policy initiatives on the Indian economy by looking at the effects of increased liquidity and credit facilities provided to the different sectors of the economy on variables such as Industry Output, Industry Employment and Consumer Spending. To provide a comprehensive assessment, the Output growth and employment for different sectors have also been examined. For the study, four scenarios have been created based on policies outlined in Atmanirbhar1.0 package. E3-India model predictions are based on the past year trends and the liquidity shock provided to it. The model provides a future assessment of growth for the next 8 years based on which future course of policy formulations has been provided. **There has been further monetary and fiscal stimulus given to the sectors through Atmanirbhar 2.0 and 3.0 which have not been accounted for in the estimation. However, the injection is much smaller than Atmanirbhar 1.0 and thus, additional packages may impact the magnitude of change across the states but trend predicted in the chapter for the states will remain the same.**

[1] Further details provided in Chapter 2.

10.2 Literature Review

It is important to understand the past recurrence of such pandemics to analyse the future policy implication. Garrett (2008) studied the pandemic implications by predicting the economic and social costs of a modern-day pandemic based on the effects of influenza in 1918 suggesting that the key to handle the pandemic is the successful cooperation and planning at all levels of the government. Brahmbhatt and Dutta (2008) studied the economic impact of SARS type infectious disease outbreaks highlighting that under the prevailing conditions of mass global communications, the spread is on a larger scale. Their study also emphasises that in such a situation, the quality communication and coordination among the organisations are important. Vital public information would help in reducing the unwarranted panic.

Qureshi (2016) studied the economic and political impact of the Ebola epidemic on West African countries—Liberia, Sierra Leone, and Guinea—which are among the poorest. These nations faced deep economic crises along with health issues, resulting in reduced productivity, lower output and decreased household income. The reduction in workforce and unemployment was the result of fewer opportunities and diversion of spending from profitable sectors to others. Many small businesses in these countries and trade businesses faced shutdowns. In response to this crisis, funding was provided by various international organisations and eventually, the growth started reaching positive figures after two years in 2016 (Cangul et al., 2017). Cangul et al. (2017). This highlights the importance of fiscal spending in such situations especially for the vulnerable groups in a flexible and timely manner. The paper draws the inference that in such situations, rapid financing and coordinated community financial support through international sources are vital to fight the recession.

In the event of current pandemic, the post-lockdown phase of the economies would require complete debt restructuring packages to ensure that all the businesses can sustain the slowdown and meet the working capital. This enhances the need to stimulate spending both for individuals and employee benefits. In light of the above implication, it is important to study the packages and approaches targeted by the various countries as a measure to combat the economic slowdown of the pandemic.

In the backdrop of COVID-19, the Government of Bangladesh has provided fiscal stimulus package amounting to 3.7% of its GDP, which is among the highest of other South Asian and South-East Asian Economies

(Raihan, 2020). The relief has been provided through financial credit in form of interest subsidies and government assurances. Working capital loans have been provided to the industries engaged in the exports sector which are among the worst hit. Under Back-to-Back Letter of Credit arrangement, the Export Development Fund of the Bangladesh Bank is increased from USD 3.5 billion to USD 5 billion to facilitate import of raw materials and pre-shipment credit refinance scheme. A refinance scheme has been introduced for the Agriculture sector and some support measures are given for returnee migrants. The article highlights that the success of such mechanism depends upon the implementation stage of the credit provision through the identification and selection of the affected firms. In addition, institutional challenges exist due to infrastructure constraints.

Sri Lanka is an example of a country which has been able to manage the spread well on the health front but due to the global economic shutdown, the important sector like tourism has been largely affected (Weerakoon, 2020). In addition, the economy of Sri Lanka had already been facing problems with a fiscal deficit and public debt as high as 6.8% and 87% of the GDP respectively. The fiscal constraint has resulted in the government resorting to the provision of relief measures through monetary stimulus and minimal fiscal packages. It relied on leaning heavily on monetary policy through sharp cuts of policy interest rates and liquidity injections through refinancing schemes and bank reserve requirements. The paper highlights that the monetary measures may help in combating the deflationary pressures in the early phases, it may induce inflationary pressures through exchange rates and imports. To control this, the government has imposed import restrictions. However, it highlights that the fiscal measures are needed to drive the multiplier growth by putting money directly in the hands of the public, boosting the employment and public spending by targeting the livelihood and income increase of the people. Hence, a long-term fiscal package along with monetary stimulus is needed in such a crisis.

Pakistan has been one such country which did not resort to the full nation-wide lockdown for a prolonged period. This is important in understanding that essentially the economic activities did not go into complete shutdown though the pandemic has disrupted the growth of these activities. Khan and Ahmed (2020) highlights that the government of Pakistan resorted to the complementary approach of both fiscal and monetary stimulus. It provided fiscal stimulus package of almost 1.6% of the GDP with emphasis upon health and disaster response, support for exporters through tax refunds, social safety programmes to the low-income population and support to the (MSME). It has provided special tax relief to the construction sectors to target the day labourers and stimulate growth in the dependent industries. Policy cuts have been done to induce the liquidity and help the distressed MSMEs with subsidised loans and credit risk-sharing facility. To finance the above measures, loans have been taken from global institutions. This will add up the debt servicing cost in the long run which needs to be met through domestic resource mobilisation in the future. The article highlights the importance of the debt management strategy for Pakistan and importance of regional cooperation in the South Asia region to enhance the transport, information and communication technology, people to people connectivity and also address the shared vulnerabilities such as health, food security and disaster risk reduction.

China which was the first country to be hit by COVID-19 has led massive economic and social rescue packages to save the economy. Despite being the highest populated country, labour force of 900 million and manufacturing constituting the big chunk of its GDP, it has performed relatively better than other countries. The biggest challenge for China over the years had been poverty alleviation as still, 600 million people live with a monthly income of 1000 yuan (US$140) or less which is way less than the country's average (Tang et al., 2020). In addition to the target of achieving zero poverty, employment sustenance has also become a task. The government of China has announced a 4 trillion-yuan package which provides tax exemptions, lower bank interest rates, waivers in contributions to social welfare funds and price reduction in important utilities like electricity. The fiscal package will be financed through bond issuance such as special treasury bonds. Also, it has emphasized the role of local government in tackling the crisis which has been authorised to fund infrastructure creation through special-purpose bonds. The likely impact of these fiscal packages may increase the government fiscal deficit but promises a positive growth in 2020 itself, which is less likely for most of the largest economies in the world. The government's approach during this time is different from that of the financial crisis of 2008, where more emphasis was laid on debt-fuelled state spending while at present, the focus of the government is creating a pro-growth environment ensuring secured employment, livelihood and market entities.

The South-East Asian Economies like Vietnam, Thailand, Indonesia etc. are gaining importance in terms of high growth potential for trade and shift in geopolitical focus. These developing countries face similar challenges of sustenance of its lower- and middle-income groups and poverty alleviation. These economies share proximity with China and were among the first few countries which faced the downturn of COVID-19. Thailand which was struggling last year due to staggering economic growth (Yuvejwattana & Chuwiruch, 2019) caused by trade wars announced a $10 billion package targeting farmers and low-income groups particularly involved in the tourism industry to bolster consumer spending and investment. However, 2019 did not see much change in growth revival when COVID-19 hit. To this, the Thai Government has started 3 phased stimulus package providing financial assistance to small and medium-sized businesses in Phase 1, tax relief for businesses and employees in Phase 2 and cash transfers to workers and labourers in Phase 3 to maintain liquidity in the financial sector and avoid the crunch of working capital (Garg & Pulipaka, 2020). The package is essentially a financial stimulus providing the credit needs of the people. However, higher reliance on external borrowing to finance this raises issues such as possible high inflation in future. The domestic strength of the economy lies in how its highest-earning sector i.e. tourism industry revives back.

Vietnam has been growing as a major export hub in recent years and has performed far better than most of the countries. It has an experience of SARS, 2003 which has prompted quick actions and containment of the spread of disease at a much faster rate. This has saved on the health costs and lockdown costs, given the cases were stopped at the primordial stage. The government of Vietnam has employed innovative ways to tackle economic activity decline. It has provided with a total of USD 11.4 billion stimulus package through tax rebates, delayed land lease fees, social security programmes and increased the spending on infrastructure projects to sustain the growth (Garg & Pulipaka, 2020). It has targeted incentives to specific sectors like wood processing, paper, passenger cars and mechanical products which very more vulnerable in the manufacturing sector. The package is inclusive of funding from Japan to tackle the supply chain management, which has been the driver for trade and economic growth in the recent times and are among the worst sectors disrupted by Global slowdown. The most innovative way of the government to handle the COVID's impact on vulnerable sections was the installation of automated rice vending machines which assisted those who lost jobs in the pandemic. Zero price stores were opened up where customers could choose five items not exceeding a set limit at zero cost. These initiatives were specially to target low income and poverty-stricken groups. On the monetary policy front, the government has actively provided expansionist policies through policy rate cuts and financial inclusion of different sections through the wider availability of credit. The State Bank of Vietnam has announced liquidity injection through refinancing windows at 0% interest rate, for Vietnam Social Policy Bank and other Credit Institution to implement the government's programmes and help institutions to handle Non-Performing Loans (IMF, 2020).

In addition to the States' assistance, International Institutions have pledged support for the Economies. World Bank Group has provided with a package of $12 billion for immediate support to help the countries tackle both health and economic crisis (World Bank, 2020). The projects will be launched as new financing through the International Development Association (IDA) for low-income countries at low-interest rates and International Bank for Reconstruction and Development (IRDA) targeting the middle-income countries. This would expand the country's capability to tackle the crisis. In addition, International Finance Corporation (IFC) will assist the corporate sectors to sustain the jobs, supply chains and limit downside risk. Along with the credit package, policy advice and technical assistance drawing on global expertise and country-level knowledge will also be provided.

It is evident that most of the countries have laid importance on fiscal spending targeting the credit expansion for the businesses and direct income support to the people. However, the past studies of the epidemics have been mostly qualitative research. This paper brings into a new way of assessment of the economic package impact over the years on the Indian Economy through E3 modelling exercise. The research stands out from the existing literature as it provides policy impact assessment through the quantitative impact on various sectors and macroeconomic variables at the regional level. It makes a forecast of the estimated growth based on past trends and the policy package adopted at present. This gives more insight into the possible effects and working of the policy and any additional course of action that could be taken to complement the working of the schemes.

10.3 Scenario Development

Indian Economy has been witnessing a slowdown for the past few years which has been aggravated by the COVID-19. The impact of the pandemic has been felt by almost the entire population, but at different rates and intensity depending upon their existing economic conditions and vulnerability. The migrant labourers, below poverty line group, as also the lower and middle-income sections engaged in MSMEs and Agriculture activities are among the worst affected. India has about 21.9% of its population below the poverty line (RBI Poverty estimates for census 2011). Besides this, more than 80% of its population is engaged in the Informal sector. This has posed a challenge to the Indian government as to how to maintain the sustainability of its population and provide them with social and income support in different ways. In May 2020 a relief package was provided amounting USD 285 billion (INR 20 lakh crores), targeting the above sections of people by giving both immediate relief and medium-term reforms to target the structural issues. The package has been termed as 'Atmanirbhar', signalling Indian Government's attempt to make India a self-reliant economy by taking the crisis as an opportunity. This section provides a comprehensive explanation of four scenarios fed into the E3 model in line with the Atmanirbhar package.

10.3.1 Scenario 1: Increase in Investment on Agriculture and MSME Sectors via Expansion of Accessible and Affordable Formal Credit and Infrastructure Development

The Agriculture and MSME sectors are the keystones of developing economies like India due to the heavy reliance of the working population for livelihood. The two sectors have been chosen to be exercised together in the model because of their mutual interdependence through backward and forward linkages and their role in employment generation, especially at a small scale in the informal sector of the Indian Economy. The Agriculture and MSMEs have been sustaining the livelihood of the lower- and middle-income groups which puts both of them at the centre-stage of the current schemes of the government.

10.3.1.1 Agriculture

The financial inclusion through accessible formal credit at affordable rates has been one of the objectives of various Agriculture policies launched in the past. However, the COVID-19 pandemic has pushed financial services to the brink. In order to revive the Agriculture sector through new packages and consolidate the already existing schemes, Atmanirbhar package has provided a corpus of USD 52.8 billion (INR 3,70,000 crores)[2] rupees for this sector (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d). Details of the various schemes and programmes are given below.

1. Credit boost to the farmers at concessional rates under already existing Kisan Credit Card Scheme to 2.3 crore farmers. These include fishermen and husbandry farmers. The total amount injected under this is USD 28.5 billion (INR 2 lakh crores).
2. The COVID-19 has a major impact on the working capital of the farmers due to shutdown of markets and disruption of supply chains. An injection of USD 4.2 billion (INR 30,000 crores) have been announced to meet emergency needs of farmers through NABARD for meeting the crop loan requirement of Rural cooperative banks and Regional Rural Banks. This is in addition to USD 12.8 billion (INR 90,000 crores) financial support provided to NABARD earlier. The additional amount is targeted to benefit 3 crore small and marginal farmers.
3. Agriculture Infrastructure fund of USD 14.2 billion (INR 1 lakh crore) will be set up to meet capital requirement of farm gate facility and aggregation points such as cooperative societies and Farmer Producer Organisation.
4. Launch of Pradhan Mantri Matsya Samapada Yojana has been announced for integrated, sustainable and inclusive development of marine and inland fisheries. USD 1.5 billion (INR 11,000 crores) will be injected for activities in Marine, Inland fisheries and aquaculture and USD 1.2 billion (INR 9000 crores) on infrastructure in setting up of fishing harbours, cold chain etc. The objective is to increase the fish production by 70 lakh tonnes over 5 years and provide employment to over 55 lakh persons, increase export to USD 14.2 billion (INR 1,00,000 crores).
5. Animal Husbandry infrastructure Development fund of USD 2.1 billion (INR 15,000 crores) will be set up to support private investment in the dairy sector. This is aimed to incentivise setting up plants for export and processing.

[2] In Atmanirbhar Package 3.0, additional fertiliser subsidy of USD 9.28 billion (65,000 crores) have been provided (PIB, 2020).

6. Promotion of Herbal Cultivation through the investment of USD 0.5 billion (INR 4000 crores) is proposed to be made by supporting 10,00,000 hectares of land in the next 2 years. This is estimated to result in USD 0.7 billion (INR 5000 crores) income generation for farmers, creation of a network of regional mandis for medicinal plants, corridor development along banks of Ganga for infrastructure and marketing support through investments.
7. The sustenance of beekeeping as rural livelihood activity will be supported through the investment of USD 71 million (INR 500 crores). This is aimed to increase the yield and quality of crops, Infrastructure development related to Integrated Beekeeping Development Centres, Collection, Marketing and Storage Centres, Post-Harvest & value Addition facilities etc. This is estimated to increase income for 2 lakh beekeepers and Capacity building for women.
8. An investment of USD 71 million (INR 500 crores) has been declared for supporting the horticulture crops i.e. fruits.

10.3.1.2 MSME

The MSME sector plays a crucial role in economic and social development due to its potential in providing employment and boosting exports. However, this sector has been struggling due to lack of credit facilities. The credit to MSME fell from CAGR of 10.9% in 2008–13 to 3.3% in 2013–18 (Economic Survey of India, 2019–20). The situation has worsened post-COVID-19 as this sector includes a major chunk of the informal economy and relies to a large extent on informal sources of finance. This might increase the debt burden due to reduced revenues and capacity utilisation. To provide relief to MSMEs in such a scenario, the Government of India has infused USD 52.8 billion (INR 3,70,000 crores) through various schemes incorporated in this scenario (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d).

1. There has been a change in the definition of enterprises classified in the MSME sector which will make it more flexible for enterprises to qualify for the benefits announced for MSMEs. To finance the emergency working capital requirement for business, collateral-free automatic loans will be provided through banks and Non-Banking Finance Companies (NBFCs). Under this scheme, interests will be relatively low and capped and the government will provide a 100%

credit guarantee to the lending financial institution. This is estimated to infuse USD 42.8 billion (INR 3,00,000 crores) in the system.

2. The formal finance to this sector will be boosted by providing equity funding to MSMEs with growth potential and viability. According to the government, this will help in generating USD 7.1 billion (INR 50,000 crores) via easy and affordable access to credit.
3. To help the distressed MSMEs with Non-performing Assets, the money will be infused via equity in these enterprises by providing loans to the promoters through banks. The government will set up the Credit Guarantee Fund Trust, which will give partial credit guarantee support to the banks under this scheme. This will help in extending USD 2.8 billion (INR 20,000 crores) of debt.

In order to assess the effects of these schemes, the model has been given an investment boost of a total amount of USD 105.7 billion (INR 7,40,000 crores) over a period of three years. The three years' timeline has been chosen based on the assumption that the amount will not be a lump sum injection but spread out over the years. The Agriculture sector has been extended to include Agriculture and allied activities. Stimulus for the MSMEs has been modelled by providing investment boost to the manufacturing[3] sectors. The sector shares for additional investment in manufacturing are based on the weightage of the sectors in their contribution to gross value-added.

10.3.2 *Scenario 2: Increase in Investment on Physical and Social Infrastructure in Order to Influence Household Expenditure and Welfare*

Physical and Social Infrastructure affects the potential for economic growth and development. Households are the focus in designing policies for inclusive growth and welfare. This requires the provision of employment opportunities, housing, accessible and affordable electricity, education and health services, physical infrastructure like airports etc.

[3] An additional USD 20.8 billion (Rs. 1.46 Lakh Crores) have been provided as production linked subsidy to 10 manufacturing sectors under Atmanirbhar Package 3.0 (PIB, 2020).

Through many initiatives, the Government of India under the 'Atmanirbhar' package has targeted these sectors which are crucial for inclusive growth in the long term.

10.3.2.1 Provision of Housing via Investments in the Construction Sector Through Interest Subsidy for Cheaper Credit

The construction sector has been given the boost through housing sector by incorporating extended dates to 31st March 2021 of Credit Linked Subsidy Scheme for Middle Income Group (CLSS) under Pradhan Mantri Awas Yojana (Urban). The Government of India has estimated that this would enable investment of USD 10 billion (INR 70,000 crores)[4] in the housing sector (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d). The investment will be attracted through easier and cheaper credit provided for housing loans to families under the scheme. CLSS provides an upfront interest subsidy of 4% to middle-income groups falling under the annual income of USD 8571 (INR 6 lakhs) to USD 17,142 (INR 12 lakhs) and interest subsidy of 3% to middle-income groups under the annual income of INR 12–18 lakhs. It has so far benefitted 3.3 lakh middle-income families. This could trigger increased demand for affordable houses and thus, helping the stressed companies. Affordable credit expands the scope of financial services in the housing sector for middle-income families. In addition, this will generate employment and increase the output for the demand-linked industries such as steel, cement, transport and other construction materials. To capture the possible effects of the above policy on the construction sector through backward and forward linkages, macroeconomic variables have been studied by employing the above in the scenario.

10.3.2.2 Increase in Investment for Social and Physical Infrastructure Creation Through Viability Gap Funding and Liquidity Infusion in Financial Enterprises

Infrastructure financing is long term in nature and is generally done by institutions like NBFCs, Housing Finance Companies, Micro Finance Institutions. However, these have been facing difficulties in raising money through debt markets. To aid such institutions, the Government has announced a special liquidity scheme of USD 4.2 billion (INR 30,000

[4] USD 2.57 billion (Rs. 18,000 crores) have been provided under PMAY-U in Atmanirbhar Package 3.0 (PIB, 2020).

crores) for both primary and secondary market transactions via fully guaranteed securities by the Government of India (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d). This will help in creating confidence in the markets and aid RBI measures and other government support. In addition to the above, the existing partial guarantee credit scheme will be extended to provide safeguards for NBFCs when they undertake fresh lending to MSMEs and individuals. This guarantee will facilitate 20% of loss borne by the Central government in the context of lenders to such NBFCs. This will help in generating liquidity worth USD 6.42 billion (INR 45,000 crores) via easy availability of credit to NBFCs for lending purposes.[5]

The other schemes undertaken by the Government of India to provide direct financing to infrastructure sectors is the Viability Gap Funding for the development of social infrastructure. The social infrastructure comprises the provision of education and health services which benefit the society at large, building human capital. The government has enhanced the funding to up to 30% of the Total Project cost. These are for the projects proposed by Central Ministries, State Government and statutory bodies. The funding is estimated to be around USD 1.1 billion (INR 8100 crores) (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d).

Further, the infrastructure development has been focused on the civil aviation sector by encouraging the Public–Private Partnership model for airport development. In order to develop world-class airports, private investments have been attracted through transparent auctioning in 12 airports of the country. This is expected to attract private investments worth USD 1.8 billion (INR 13,000 crores) in the given sector. All the above policies targeting infrastructure development through different modes of financing have been checked for their given role in economic growth through credit generation and asset creation.

[5] The government under Atmanirbhar Package 3.0 has infused additional USD 0.85 billion (Rs. 6000 crores) equity in National Infrastructure Investment Fund. This will be provided through NBFC debt platform and NBFC infrastructure company (PIB, 2020).

10.3.2.3 Increase in Investment for Coal Sector Through Credit Provision for Infrastructure Development and Boost Domestic Production

The coal sector has been riddled with low domestic production due to restrictions and the monopoly of Coal India Power Ltd. in its production. The target of the Mineral Laws (Amendment) Bill 2020 is to enable ease of doing business, reduce regulations on the coal sector, improve the competency and transparency in coal mines allocation. The purpose stated is to crowd in private investment by simultaneously reducing government restrictions and increase the public expenditure on infrastructure and provide attractive incentives through revenue sharing mechanisms. For the above purpose, USD 7.1 billion (INR 50,000 crores) infrastructure development fund will be set up including USD 2.5 billion (INR 18,000 crores), exclusively for investing in the mechanised transfer of coal (conveyor belts) from mines to railway sidings (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d). This would help in achieving coal production of over 1 billion tons by 2023–24 in addition to the coal production by private blocks. The other regulatory measures include removing the distinction between captive and non-captive mines to enable the transfer of mining leases and sale of surplus unused minerals. The investments in Coal Gasification/Liquefaction are to be incentivised through rebates in revenue share. This would help in switching to a gas-based economy in long term. The significant steps taken might increase the efficiency in both mining and production, resulting in improved employment opportunities in the given sector, increased output and thus, helping in long-term self-sufficiency. The improved supply management of coal sector would have productive effects in reducing imports and better procurement strategies for electricity generation companies. The better techniques will help reduce environmental impacts.

10.3.2.4 Increase in Investment for the Electricity Sector Through Liquidity Injection in Debt-Ridden Distribution and Transmission Companies for Accessible and Affordable Electricity Supply

The electricity sector has been struggling for the past few decades due to the miserable financial health of Distribution and Transmission companies (DISCOM) and complex regulatory structure. COVID-19 has adversely impacted this sector due to the subdued demand which has resulted in enlarging debts, non-payment to the generation companies and inability to meet even the working capital requirement. DISCOMs have to pay USD 13.4 billion (INR 94,000 crores) to power generation companies. To provide relief to this sector, tariff policy reforms and liquidity has been infused to help the debt-ridden sectors. An additional amount of USD 12.8 billion (INR 90,000 crores) has been injected for DISCOMs to help them meet cash flow for sustenance against receivables. Loans will be given against the state guarantees for purpose of discharging the liabilities and will be provided from Power Finance Corporation and Rural Electrification Corporation. Central Public Sector Generation companies shall provide rebates to DISCOMs. To facilitate the transmission to the final consumers i.e. industries, digital payment facility, liquidation of outstanding dues of State Governments and reduction in financial and operational losses will be done. Standards of services and penalties will be set up along with the elimination of regulatory assets. Regulatory asset funds belong to DISCOMs but are kept with the state government which can be recovered at a later stage of time. This capital through this fund will help in enhancing the liquidity of DISCOMs. In addition to the above, to simplify and reform the tariffs, cross-price subsidies may be eliminated by shifting to Direct Benefit Transfer for eligible customers. The increased investment of USD 12.8 billion (INR 90,000 crores) will be injected in the model to check for consequent effects on the macroeconomic variables for the model which will help in solving existing rigidities in the sector for quality supply of electricity to all the areas (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d).

The above investment of USD 44.8 billion (INR 3,14,200 crores)[6] has been injected in the model as per the sectors most appropriate for the above policies.

10.3.3 Scenario 3: Increase in Income Through Direct Benefit Transfer, EPF Support and Liquidity Infusion in MNREGA

The lockdown has severely put a constraint on the regular income and savings of the working classes. The migrant labourers and misery of the poor have been primarily due to the loss of financial sources. As an income support measure to the above groups, the policy has been devised through multiple components provided in Table 10.1.

[6] Additional investment in capital industry has been made under Atmanirbhar Package 3.0 for USD 1.45 billion (Rs. 10,200 crores) (PIB, 2020).

Table 10.1 Components of income support policy scenario

Component	*Amount in USD million (In INR Crores in parentheses)*
Employee Provident Fund relief	8507 (59,550)
Income support policy for migrants and farmers	1214 (8500)
Liquidity infusion through MGNREGA	5714 (40,000)
Pradhan Mantri Garib Kalyan Yojana (PMGKY)	24,285 (1,70,000)

Source (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d)

Pradhan Mantri Garib Kalyan Yojana (PMGKY) is an ongoing scheme which has been infused with additional capital to provide free food grains and cash payment to the women and poor senior citizens and farmers. The scheme has provided an estimate of benefitting 420 million poor people through the financial assistance of USD 9.3 billion (INR 65,454 crores) in the past. The scope of the scheme has been expanded through liquidity infusion by providing insurance cover of USD 71,428.57 (INR 50 lakh) per health worker. An estimated 80 crores of poor people are to be given the benefit of rationed and free pulses and rice through this. The importance of Jan Dhan account coverage has been highlighted by transferring around USD 7.1 (INR 500) per month to women for coming months. Ex-gratia of USD 14.2 (INR 1000) will be given to 30 million poor senior citizens, poor widows and Divyang (differently-abled persons). The policy has been targeted at multidimensional levels. To expand the financial services to women and poor workers, the limit of collateral-free lending will be increased from USD 14,285–28,571 (INR 10–20 lakhs) for Women Self Help Groups supporting 6.85 crore households. Wage support to workers will be given through PF accounts and District Mineral Fund will be used for supplementing and augmenting facilities for migrant poor.

Employee Provident Fund (EPF) support will be provided in many ways. Around five crore workers registered under EPF will get a non-refundable advance of 75% of the amount or three months of the wages, whichever is lower, from their accounts. The government had made payment to their EPFs amounting to 12% of employer and 12% of the employee of eligible establishments for the months of March to August. This is estimated to provide liquidity relief of USD 0.35 million (INR 2500 crores) to businesses and workers. The Statutory PF contribution of both the employer and employee will be reduced from 12 to 10% each for all establishments covered by EPFO applicable to those who are not eligible to earlier 24% support. A special scheme for street vendors has been launched to facilitate easy affordable credit access. Under this scheme, bank credit will be provided to each vendor for an initial working capital of up to USD 142.8 (INR 10,000). This is estimated to generate liquidity of USD 0.7 million (INR 5000 crore).[7]

Under the existing Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), an additional amount of USD 5714 million (INR 40,000 crores) has been allotted to meet the increased demand for work due to the huge migration and other economic activities being affected. This is estimated to generate 3000 million person-days of work. The aim is to give a boost to the rural economy through higher production and income support. Average work rates have been revised which will give more money in the hand of the workers. There has been a plan to extend the scheme in monsoon days as well for agricultural needs. This will target the creation of a larger number of durable and livelihood assets including water conservation and other infrastructure like livestock-related sheds. The above policies will directly put money in the hands of the people and consequently increase their disposable income. The aim is to look at its effect on consumer spending, its effect on macro-level output through infrastructure and asset creation. For income support policy, the below poverty line group has been chosen to check for their upliftment regarding direct monetary benefits. In addition, Employee Provident Fund Relief has been checked for the middle-income and lower-income group. This is based on the eligibility criteria of the Atmanirbhar package for the given schemes. This would help in checking for the impact of both liquidity through credit and direct benefit transfer.

[7] Under Atmanirbhar Package 3.0. Bharat RozgarYojana for USD 0.85 (Rs. 6000 crores) have been launched through additional provisions for EPFO establishments (PIB, 2020).

To check for the given scenario, the regional income of the people has been increased as per the different amounts allocated to the households under the above scheme.[8]

10.3.4 Scenario 4: Liquidity Infusion in Manufacturing Sector Through RBI Monetary Expansion via Quantitative and Qualitative Measures

RBI being the central bank of India and the commander of the monetary policy have direct involvement and responsibility to expand the scope of financial services available to people through the direct and indirect monetary instrument in its hand. RBI to serve the purpose of monetary expansion in light of COVID-19 and economic slowdown going on in India for past years have devised various liquidity measures. These include-

1. Cash Reserve Ratio (CRR) was reduced which resulted in liquidity support of USD 19.5 billion (INR 1,37,000 crores) by making more money available to the banks for credit provision.
2. Banks' limits for borrowing under the marginal standing facility (MSF) were increased, allowing banks to avail additional USD 19.5 billion (INR 1,37,000 crores) of liquidity at reduced MSF rate.
3. USD 21.4 billion (INR 1,50,050 crores) of Targeted Long-Term Repo Operations (TLTRO) has been planned for investment in investment-grade bonds, commercial paper, non-convertible debentures including those of NBFCs and MFIs.
4. Special Liquidity Facility (SLF) of USD 7.1 billion (INR 50,000 crores) was announced for mutual funds to provide liquidity support through financial instruments.
5. Special refinance facilities worth USD 7.1 billion (INR 50,000 crores) were announced for NABARD, SIDBI and NHB at policy repo rate to sustain their financial health in case of credit repayment delays.
6. A moratorium of three months has been provided on payment of instalments and interest on working capital facilities for all types

[8] Atmanirbhar Package 3.0 provides additional USD 1.42 billion (Rs. 10,000 crores) to boost rural employment (PIB, 2020).

of loans in light of lockdown for providing space to the creditors without making them go bankrupt.

7. NBFCs have been facing liquidity crunch due and thus, relief has been given in form of additional time of one year for loans repayment to commercial real estate sector for commencement for commercial operations (DCCO).

The measures taken in form of both qualitative and quantitative form have been targeted to expand the scope of banks to provide credit to the revenue crunched businesses. RBI has not specifically mentioned where the infused amount will be directed. However, keeping in mind the objective of Atmanirbhar in which the Government of India through Make in India and Going local wants to expand the sectoral share of the manufacturing sector. In this scenario, liquidity infusion of RBI has been provided as an investment shock to the manufacturing sectors in E3-India model. This will provide insights on how if this entire liquidity is infused into manufacturing, what will be the consequent effects of it. The given scenario will check for the change in the growth in output and employment of manufacturing sectors and their indirect effect on the services sectors. In addition, Consumer spending and trade will be checked which will help in the assessment of the given infusion on the households and trade through manufacturing growth, the long-term targets of Government policies.

For the above RBI measures, the stimulus of USD 114.5 billion (INR 8,01,603 crores)[9] have been injected in the model over a period of three years as investment in manufacturing based on the assumption that the Government of India will spread the total liquidity over a period of time and the liquidity will have a lag period before the increase in credit availability affects the economy.

The following table summarises the overall scenario development created for the analysis (Table 10.2).

The results and discussion are provided based on the scenarios created to comprehensively analyse the Atmanirbhar Package 1.0. The different sectoral growth for industry output and employment are highlighted

[9] In year 2020, additional USD 67 billion (Rs. 4,69,597crores) have been provided through various measures by Reserve Bank of India.

Table 10.2 Summary of scenarios: Atmanirbhar package

Sr. no	*Scenarios*	*Description*	*Sectors*	*Monetary allocation in USD billion (INR crores)*
1	Agriculture and MSME	Increase in investment on Agriculture and MSME sectors via expansion of accessible and affordable formal credit and infrastructure development	**(A) Agriculture etc**	
			(i) Kisan Credit Card Scheme	28.5 (2,00,000)
			(ii) Additional Emergency Working Capital for farmers	4.2 (30,000)
			(iii) Agriculture Infra. Fund	14.2 (1,00,000
			(iv) PMMSY	2.7 (20,000)
			(v) Animal Husbandry Infra. Development Fund	2.1 (15,000)
			(vi) Herbal Cultivation	0.5 (4000)
			(vii) Beekeeping	0.071 (500)
			(viii) Horticulture	0.0071 (500)
			Sub-Total (A)	**52.8 (3,70,000)**
			(B) MSME	
			(i) Collateral-free Automatic Loans for	42.8 (3,00,000)
			(ii) Equity Infusion	7.1 (50,000)
			(iii) Subordinate Debt	2.8 (20,000)

(continued)

Table 10.2 (continued)

Sr. no	*Scenarios*	*Description*	*Sectors*	*Monetary allocation in USD billion (INR crores)*
			Sub-Total (B)	**52.8 (3,70,000)**
			(I) TOTAL (A + B)	**105.7 (7,40,000)**
2	Physical and social infrastructure	Increase in investment on physical and social infrastructure in order to influence household expenditure and welfare	(i) Housing for Middle Income groups under PMAY	10 (70,000)
			(ii) Viability Gap Funding	1.1 (8100)
			(iii) Coal	7.1 (50,000)
			(iv) Airports	1.8 (13,000)
			(v) Liquidity infusion for DISCOMs	12.8 (90,000)
			(II) TOTAL	**32.8 (2,32,100)**
3	Income support policy	Increase in income through direct benefit transfer, EPF support and liquidity infusion in MNREGA	Employee Provident Fund relief	8.5 (59,550)
			Income support Policy for migrants and farmers	1.2 (8500)
			Liquidity infusion through MGNREGA	5.7 (40,000)
			PMGKY[a]	24.2 (1,70,000)
			(III) TOTAL	**39.6 (2,78,050)**
4	RBI measures	Liquidity infusion in manufacturing sector through RBI monetary expansion via quantitative and qualitative measures	**(IV) TOTAL**	**114.5 (8,01,603)**

(continued)

Table 10.2 (continued)

Sr. no	*Scenarios*	*Description*	*Sectors*	*Monetary allocation in USD billion (INR crores)*
6	**GRAND TOTAL (I + II + III + IV)**			**293.1 (20,51,753)**

Source (Ministry of Finance, GOI, 2020a, 2020b, 2020c, 2020d)
Note [a]The total amount allocated for PMGKY is USD 27.5 billion (INR 1,92,800) of which USD 1.1 billion (INR 7800 crores) is through tax concessions and USD 2.1 billion (INR 15,000 crores) is in Health sector. Since it is not directly linked with income support through PMGKY, they have been excluded here.

along with the potential sectors where the growth may happen due to the benefits accrued by the package in the pandemic hit economy.

10.4 Results and Discussion

The forecast of the model has been assimilated for the given sectors under a different scenario to bring out the working of the policies. The average of the percentage difference from the baseline has been treated as the growth rate over the years for the variables. The averages of the growth of the given variable under the scenario have been taken from 2020 to 2028. The period has been chosen based on the assumption that the Atmanirbhar policy has been targeted in short to medium term. It has been observed that for the period beyond 2028, the growth rates are dropping down, demanding the different set of policies in the regions to sustain the growth taken place over the years.

10.4.1 Scenario: Agriculture and MSME

The focus of the government in the past few years has been primarily on the MSME and Agriculture sector. The Atmanirbhar package has put special emphasis on both of these sectors which support the informal sector of the economy which are among the hardest hit due to COVID 19. The MSMEs and Agriculture sectors have been clubbed together to study the impact on the informal economy which has been facing structural challenges in its growth for a couple of years. They have been at the forefront of Government's policies due to credit crunch and their heavy reliance on informal sources. Atmanirbhar package has been striving to meet their credit demands, especially for the working capital through concessional loans, credit guarantee, collateral-free loans and extension in their loan maturity. The impact of these policies at sectoral level has been captured by studying the overall Industry output and employment and the effect on the consumer spending. The Average of the percentage difference of the growth rate from the baseline is depicted for the top-performing states in Fig. 10.1.

The Average of the percentage difference of the growth rate from the baseline growth rate for GDP is approximately 1%. The states of West Bengal, Uttar Pradesh, Haryana, Assam, Gujarat have higher than All India Average growth rate. The growth rate of Agriculture and MSME are closely monitored due to their capacity to generate employment. It can be seen from the figure that though the employment has seen positive growth rate in these states, but the rate is less than the overall growth rate in Industry output. The Average of the percentage difference of the growth rate from the baseline for All India Industry output and employment is 0.95% and 0.74% respectively. The states which are

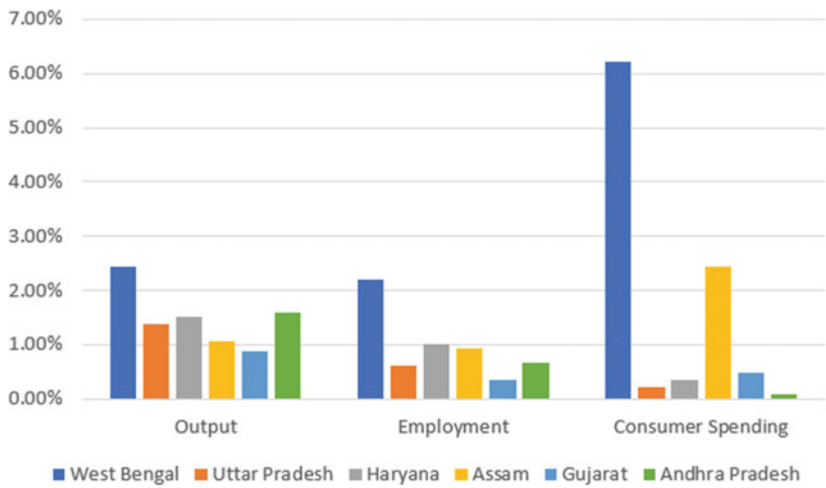

Fig. 10.1 Average percentage difference from baseline for macroeconomic impacts (2020–28) (*Source* Results from the model)

emerging among the top performers are the ones which have been relatively doing well in both Agriculture and MSMEs. The MSMEs are largely concentrated in the regions of West Bengal, Uttar Pradesh, Gujarat and Andhra Pradesh (Ministry of MSME, 2018–19). Though Assam has lower number of MSMEs in comparison to rest of the states in this category, it has performed much better than other North Eastern States. Haryana has a smaller number of MSMEs and hence, the reason of the growth in macroeconomic indicators could have been largely as a result of Agriculture growth. The growth is best illustrated through consumer spending. It signals how much of the aggregate demand has been generated as a result of the growth in these sectors. Except Assam and West Bengal, all the other states show minimal incremental growth rate over the baseline in consumer spending. The states of Assam and West Bengal showing higher than average growth rate of output and employment in consumer spending indicates positive signals. It highlights how the given policy might help in benefitting the rise in household income to finance consumer spending. The two states are among the agriculture dependent states conforming to the results that the sectoral shocks would stimulate larger spending in these states than the other higher income states. The Average of the percentage difference of the growth rate from the baseline for the output for these states is slightly above the employment levels but the lower employment levels raise a question on the sustainability of this growth in long run. A closer look at sectoral levels would provide a more comprehensive picture.

From Table 10.3, it can be seen that the Agriculture sector performs relatively better in terms of output but the employment generated remains at lower levels. West Bengal, Haryana and Uttar Pradesh which were best performers at the macroeconomic level, continue to hold this position but, in terms of employment, these states lack the potential and have been replaced by Bihar, Kerala and Assam in this aspect. Food, Drinks and Tobacco along with Agriculture capture the impact on food processing industries. The government policies have been aimed at improving the regulatory regime and infrastructure facilities. West Bengal continues to dominate, followed by Haryana and Karnataka. According to the Ministry of Food Processing Industries (2020), Uttar Pradesh and West Bengal have the highest number of registered and unincorporated food processing units (combined) with a share of 14.1% and 12.9% respectively of the national level. As per Invest India, West Bengal has among the highest cold chain infrastructure (GOI, 2020). This phenomenon is

Table 10.3 Average percentage difference from the baseline for sectoral impact (2020–28)

Sr. no	*Range*	*Sector*	*Output*	*Employment*
1	Below 5%	Textiles and clothing	Odisha, West Bengal Maharashtra	Delhi, Odisha, Maharashtra
		Trade and logistics	Assam, Andhra Pradesh, Haryana	Punjab, Assam, Haryana
		Food drinks and tobacco	West Bengal, Haryana, Karnataka	Bihar, Haryana, Karnataka
		Leather	Andhra Pradesh, Gujarat, Maharashtra	Andhra Pradesh, West Bengal, Gujarat
2	Above 5%	Rubber and plastic	Andhra Pradesh, Assam, Haryana	Assam, Uttar Pradesh
		Agriculture	West Bengal, Haryana, Madhya Pradesh	–

Source Results from the model

common for the states which are appearing among the top performers. Also, these states are among those with existing investments in Mega Food Parks. These Mega food parks have been established as a cluster-based approach where farmers and food processing units will be able to enter into a contract. Special concessions will be given to MSMEs. These parks have been further supplemented through investment in cold chain infrastructure and Agriculture investment funds to meet the credit requirements. Assam being the only North-Eastern state with existing Mega food park and other existing infrastructure facilities, explain the positive results generated. The sectors like textile and apparels, rubber and plastic and leather show positive growth. However, the growth in trade and logistics is lower than the rest. These sectors range below 5% growth rate and thus, it is expected that the additional benefits released under Atmanirbhar Package 3.0 to boost the credit provision to industries like textiles directly may help in retaining higher growth rate. The sectoral growth highlights the potential of these states in the given units. These may help in providing direction to the MSMEs in these states towards the potential sectors. Other states with similar geographical and economical structure may progress in the similar manner with additional incentives towards their infrastructure and credit availability. States like Bihar may work on the lines of West Bengal and attract food processing units to boost its regional output and employment. The analysis of the result reveals that the states which had existing industrial or Agriculture base along with infrastructure are the ones benefitting the most from the Atmanirbhar package. Further, the indirect impact study would help in better assessment.

Table 10.4 presents the percentage difference from baseline for indirect impact assessment on the services. The expansion of the manufacturing sector results in the creation of demand for ancillary services such as transportation, communication, business and insurance services, basic amenities and others. Since, the growth has been expected in the manufacturing sectors given in Table 10.4, the demand from those would help in indirect growth of the services. These services grow as the support system to the manufacturing and also, by their increased demand due to the increase in income and living standards of the people as a result of growth.

Based on Table 10.4, it can be analysed that the growth can be expected in the services sector as a result of growth in MSME and Agriculture sectors. The transport services especially land transport sees the positive growth. The basic amenities like gas, electricity and water supply shows a growth of more than 10%. West Bengal and Uttar Pradesh show very high growth in electricity supply. This might be because of the increased demand in the sectors given the boost to MSMEs like

Table 10.4 Average percentage difference from baseline for indirect impact on output of service sector (2020–28)

Sr no	*Range*	*Sector*	*Output*
1	Below 10%	Air transport	Haryana, J&K, Maharashtra
		Construction	West Bengal, J&K, Delhi
		Hotel & catering	J&K, Haryana, Gujarat
		Other business services	Assam, Gujarat, Andhra Pradesh
		Banking and insurance	Haryana, West Bengal, J&K
2	10% to 20%	Gas supply	Assam, Chhattisgarh
		Water supply	Chhattisgarh
3	Above 20%	Electricity supply	West Bengal, Uttar Pradesh, Haryana
		Land transport	Tamil Nadu

Source Results from the model

food processing and agriculture. With an exception to Chhattisgarh and Jammu and Kashmir, most of the states performing better in services continue to be the same as seen in Table 10.3. This indicates that the boost to MSME and Agriculture may help in accelerating the provision to basic services like electricity supply, water and gas supply through increased demand.

The Average of the percentage difference seen in the growth of basic amenities and transport indicates that the future MSME and Agriculture sector growth would benefit from the easy availability and expansion of such services. The provision of credit to MSME and Agriculture sector along with the growth in output and basic services as seen in Tables 10.3 and 10.4 can help in studying the impact of growth and additional investment on the trade. The growth model of most of the Asian Economies, especially China has been trade-driven especially with the help of advancement in MSMEs. The Government of India has been trying to put focus on the export-driven MSME growth along with capitalising on its potential for export of Agriculture commodities to other nations. Figure 10.2 shows the states that are showing the highest growth rate in terms of trade. The Average of the percentage difference from the baseline for All India growth for both imports and exports is below 1%. In all the top-performing states, the imports are higher than the export growth. The maximum difference between the two can be seen in Andhra Pradesh and

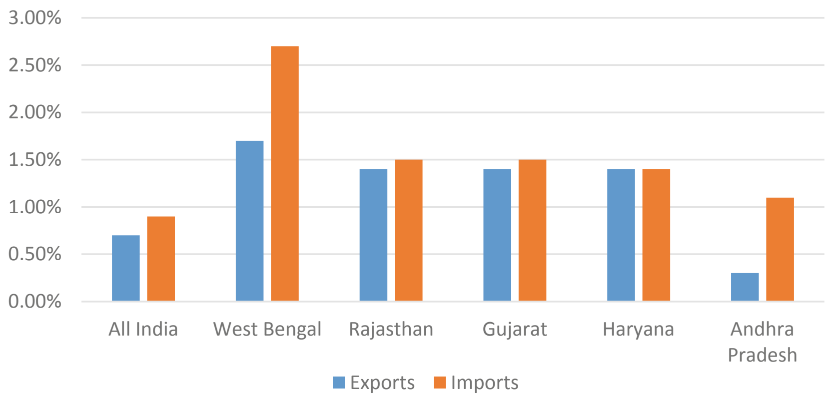

Fig. 10.2 Average percentage difference from baseline for inter-regional and international imports and exports (2020–28) (*Source* Results from the model)

West Bengal while the rest of the three states have modest differences. This shows that though the trade might show a positive growth rate, the exports continue to lack behind imports.

The highest average growth in both exports and import has been seen in West Bengal which is much higher than the All India Average. Except Rajasthan, all the other states are among the best performers in the direct and indirect growth assessment provided in Tables 10.3 and 10.4. The growth in manufacturing and services in the respective states explain the growth in trade as the potential and capacity would likely to increase. However, these are among the developed states. One of the striking features in the growth of the trade is that Haryana and Rajasthan are the two states not having the coast. Haryana has good road transport but the possible reasons for Rajasthan to perform better in terms of Agriculture and MSME trade needs to be explored. Rajasthan being the landlocked and water-scarce nation has performed relatively modest in comparison to states like Gujarat. The state is among the 4th largest producer of coarse grains and increased its focus in the recent years to expand the infrastructure especially the transport and services to boost up exports in merchandise like textiles, gems and jewellery, Agriculture and service exports like tourism (Government of Rajasthan, 2018). The Agriculture Food parks, solar infrastructure to meet the electricity demand and investment in technology to boost the productivity of Agriculture in water-scarce regions could be contributory to its growth.

It can be observed that the backward and North Eastern regions have not seen much growth with the boost in Agriculture and MSME sector. Also, even among the already existing rich states, the benefits are unevenly spread. This requires that the special focus on the backward regions must be made while expanding the credit in Agriculture and MSME. This requires development of adequate infrastructure and services in such regions to attract investment. Adoption of latest technology would help in dealing with productivity issues in the tough terrains and water-scarce regions. This would require adequate focus on the credit availability for setting up of service providers, manufacturing hubs dealing with mechanised equipment and food processing industries for value addition. The focus on setting up of labour-intensive manufacturing industries are needed to fill the gap between output and employment. Given the demographic dividend, it is important to create additional employment opportunities and bringing the informal sectors to formal economy for better social support provision to the labourers.

The additional package announced under Atmanirbhar 3.0 would help in boosting the agricultural productivity and meeting working capital needs. Though the impact on the MSME and food processing industries will be limited as the special focus on backward states for infrastructure creation is missing.

10.4.2 Scenario: Investment in Physical and Social Infrastructure

The current scenario targets the credit provision in meeting the financial obligations for projects providing for Physical and Social Infrastructure. These will aid in providing benefits to the households through basic amenities. This is done through Viability Gap Funding for airports, concessional loans to Non-Banking Financial Institution, funding to the electricity sector for meeting losses. These tend to increase GDP growth through output expansion. However, since the gestation period to such projects is long, one might expect more gains in long run than in the short run. The expansion of these is to target the underserved areas of the country. The infrastructure spending stimulates the output and employment growth through better supply chains and aggregated demand. Consumer spending in this regard is treated as the proxy for aggregated demand. Figure 10.3 shows the top-performing states in terms of average growth in consumer spending. **The average of the percentage difference from the baseline has been treated as the growth rate over the years for the variables.**

It can be seen from Fig. 10.3 that the North-Eastern States and low-income states dominate the top performers in consumer spending. Nagaland and West Bengal show an average growth rate of more than 1% in consumer spending while except Assam and Odisha, other states are less than 0.5%. It has been found during the study that the average rate of GDP growth is more than the average growth in consumer spending. This comes from the general interpretation that though the infrastructure spending stimulates GDP growth but getting translated into aggregate demand might take a lag. This is because the fiscal stimulus measures through credit take time to put money into the hands of the households, unlike the Direct benefit transfer measures which are direct income support policy measures. However, the growth in North-Eastern states and hilly states reflect that the benefits are taking place in the right direction as intended by the policy measures which targeted the underserved areas. Assam and West Bengal have benefitted in other scenarios

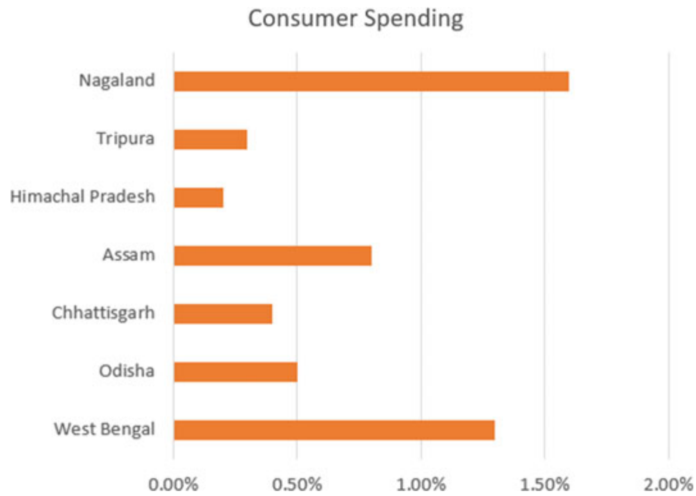

Fig. 10.3 Average percentage difference from baseline for Consumer spending (2020–28) (*Source* Results from the model)

as well since these are relatively more developed regions. This implies that the two states are reflecting positively for most of the policy stimulus under the Atmanirbhar package. The industry output and employment are studied to analyse the impact of the investment in infrastructure on the real sectors of the economy.

Figure 10.4 shows the top-performing states when estimated in terms of average growth for industrial output and employment. The Average of the percentage difference from the baseline for All India Industry output growth is 0.4% and All India industry employment growth is 0.21%. This phenomenon of lower, almost half the growth in employment than that of output has been observed for other scenarios as well. This reflects the Indian trend of lower employment growth and failure in the transition of manufacturing industries in generating employment to people. However, it must be noted that since most of the infrastructure industries are capital intensive and thus, this trend is largely expected.

It can be seen from Fig. 10.4 that the states which showed high consumer spending continue to be the top performers. The highest growth in industry output is seen in Odisha followed by Tripura and Chhattisgarh. Manipur and West Bengal are the only states which show

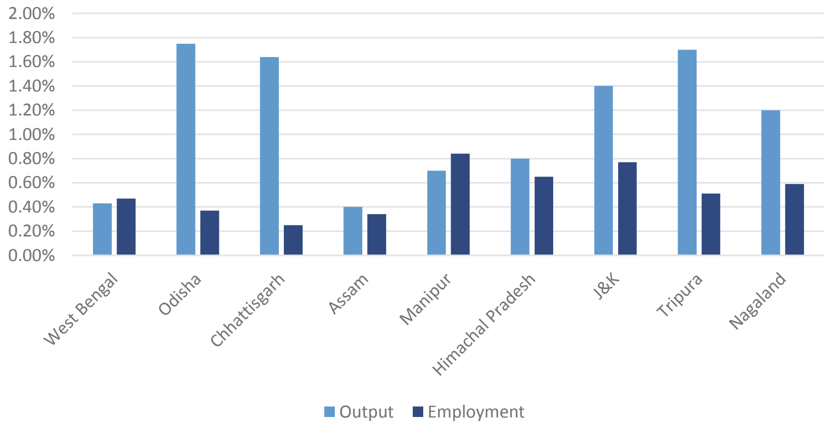

Fig. 10.4 Average percentage difference from baseline for industry output and employment (2020–28) (*Source* Results from the model)

higher employment growth than the output. The government has also given special emphasis for the development of North-Eastern states for improving the standard of living through various skill development schemes which are executed through better public administration as well as better educational services. Jammu Kashmir has also been given special attention by the central government over the past few years through various economic reforms in order to increase the economic integration within the country and we see there is an increase in output and employment levels in the region.

Table 10.5 shows the direct impact on the industry output of the sectors which have been stimulated to estimate the impact on the economy. Since these sectors are directly provided benefits under the policies, it is expected to increase the industry output growth more in it in comparison to the other sectors.

It can be seen from Table 10.5 that except air transport, the average industry output for coal, electricity, construction and banking and insurance is less than 5%. All the sectors show employment growth below 5%. Maharashtra, Chhattisgarh and Andhra Pradesh have been the top performers in coal output. These states have large coal deposits and tend to benefit more in terms of support. However, Chhattisgarh does not show up as the top performer in the employment generation in this sector.

Table 10.5 Average percentage difference from baseline for sectoral industrial output and employment (2020–28)

Range	*Sector*	*Output*	*Employment*
Below 5%	Coal	Maharashtra, Chhattisgarh, Andhra Pradesh	West Bengal, Maharashtra, Andhra Pradesh
	Electricity	Manipur, Andhra Pradesh, West Bengal	Andhra Pradesh, Nagaland
	Construction	Delhi, Odisha, Tripura	Jammu & Kashmir, Tripura, West Bengal
	Banking & insurance	Andhra Pradesh, Chhattisgarh, Karnataka	Karnataka, Chhattisgarh, Jharkhand
Above 5%	Air transport	Chhattisgarh, Pondicherry	-

Source Results from the model

Since 65% of the power in India is coal-dependent, electricity generation in these states has also seen a rise in addition to the financial package announced for the debt-ridden DISCOMS (Mukul, 2020). The North-Eastern states besides the ones shown in Table 10.5 have performed relatively better in the electricity sector. This could be because of the importance given to the construction and expansion of Hydropower over the last few years in India to expand the Renewable Energy Sources for electricity generation. Further, States such as Nagaland and Tripura are also rich in hydrocarbon resources such as Natural gas reserves. Over recent years, the government is also exploring better utilisation of natural gas not only for domestic purposes but for cross-border trade with neighbouring countries as well. Recently, the government has announced its intention of expanding cross-border electricity trade with ASEAN countries, through Myanmar with which India shares the border. As a result, emphasis on infrastructure development for electricity generation is given in the region.

The construction sector is studied in the context of the housing construction under the Pradhan Mantri Awas Yojana which has been given a further boost in the Atmanirbhar package through better financing to the Housing Finance Companies to provide credit to the lower-income groups for housing construction. Delhi, Odisha and

Tripura perform relatively better than the other states. Banking and Insurance are studied to capture the impact of financing provisions given through NBFCs. Although, Andhra Pradesh and Karnataka are among those developed states with better banking and financial services the stimulus helps in better growth in Chhattisgarh and employment generation in Jharkhand. These are among the underdeveloped regions which have lacked behind in the financial services expansion. This would help in expanding the scope of credit provision to the businesses who are trying to capture the resource-rich under-developed regions in these states and at the same time, create employment opportunities. At the same time, better services also mean financial inclusion for the households in such states as credit expansion incentivise the banking and insurance sectors to expand their service provisions in such regions.

The air transport is the only sector which shows above 5% growth with Chhattisgarh and Puducherry as the top performers. Though the employment generation is negligible, the state and UT has been among the underserved areas. The UDAN scheme through which the Viability Gap Funding is to be provided for airport construction and airline services will benefit these two regions. However, the target is to expand the scope of its benefits to North East and hilly regions which have a poor connection. Though both Puducherry and Chhattisgarh have poor airline connection but, these regions have good land transport which is lacking in the North East and Hilly areas. The employment generation because of the increase in airport output has been negligible. This might be due to the capital-intensive nature of airport construction and maintenance. The increase in output could be because of better usage of existing infrastructure. Hence, one might need to target the Viability Gap Funding through UDAN to such regions through special project focus and other benefits to attract private sector's investments.

The infrastructure development generates backward and forward linkages in the given regions generating growth for the other sectors in the regions. Table 10.6 presents the Average of the percentage difference from the baseline of sector-wise industry output and employment, for the purpose of evaluating indirect impact.

From Table 10.6, it can be seen that the investment in Physical and Social Infrastructure has generated growth in most of the sectors. The highest growth which is above 10% is seen in the oil and gas and metal goods sectors. Both of these sectors benefit from the better electricity provision and transport. The top-performing states among the sectors

Table 10.6 Average percentage difference from baseline for indirect sectoral impact on industrial output and employment (2020–28)

Range	*Sector*	*Output*	*Employment*
Below 5%	Agriculture	Odisha, Tripura, West Bengal	Odisha, Tripura, Chhattisgarh
	Basic metals	Chhattisgarh, Karnataka	Chhattisgarh, Jharkhand
	Manuf. fuels	Chhattisgarh, Odisha, Jharkhand	Odisha, Jharkhand, Tamil Nadu
	Trade and logistics	Chhattisgarh, Nagaland	Himachal Pradesh, Nagaland
5–10%	Chemicals	Delhi	-
Above 10%	Oil & gas	Andhra Pradesh	Tripura
	Metal goods	Andhra Pradesh, Odisha	-

Source Results from the model

are resource endowed especially the Chhattisgarh, Jharkhand and Odisha region. The growth in agriculture is stimulated through infrastructure development in the states like Tripura, Odisha and Chhattisgarh which were showing not much impact under Scenario 1. This highlights the need of adequate social capital formation to benefit from the development of sectoral growth. The growth in trade and logistics is again happening in the hilly states like Himachal Pradesh, the backward states like Nagaland. These states have been underdeveloped in their transport connectivity which have posed logistical challenges for industries to set up in the past. Only Delhi shows growth in the chemicals above the All India average at the rate between 5 to 10% signalling spread-out effect on chemical industries of the infrastructure. This indicates that if adequate investments are made to provide basic services to the people through changes at the sectoral level, it could boost up the potential and growth even for the backward regions. The investments in social and physical infrastructure have long gestation period but their role in regional development of the economy is crucial and must be considered in future policies as well. This will give space and encouragement to private investment which will help the households in the region with improved employment opportunities and better standards of living. The lower employment though indicates that the labour-intensive industries must be categorically targeted while the policy formulations are done.

10.4.3 Scenario: Income Support Policies

The income support policy was aimed at directly benefitting the households through direct benefit transfer (DBT) and contribution to employee provident funds. DBT has been specifically targeted for below income household groups to support them through the pandemic. Further support through indirect measures has been made for lower to middle-income groups. These measures have been made for a transitionary period of the pandemic until the economy picks up. The motive behind these measures is short term in nature and is expected to get reflected in the sustenance of the demand than the growth creation in the economy. However, these measures play an important role in understanding how the financial inclusion policies so far have facilitated in ease of amount transfer to the targeted households. The macroeconomic variables have been studied to look at the impact of the given policy.

The growth in overall GDP at All India level is 0.07% in response to the income support policy measures. Given how these have been targeted to benefit the lower-income groups, the growth primarily is stimulated through demand from the households. The Average of the percentage difference in Consumer spending at an All India level showed an average growth of 0.18% which is quite impressive growth given this is largely sustained by lower-income groups. The big states as revealed in GDP growth continue to perform better at an All India level. These could be primarily because of the factors like better targeting policy measures. Figure 10.5 provides for the relative difference from baseline for Regional GDP, consumer spending and industry output.

From Fig. 10.5, it can be seen that the Average of the percentage difference in Regional GDP is modest than the rest of the scenarios with the highest growth seen in Delhi. The states that have responded well to the income support policy measures are generally the big states. These states have good institutional capacities to reach the poor through financial inclusion. In addition, the cities support a higher population of such groups which fall into the migrant and below poverty line category which has been the foremost target under the Atmanirbhar package. Though the impact as discussed is quite low in the long run, the direct benefit transfer scheme is expected to lead to an improved standard of living which translates into better education and job opportunities leading to increase in GDP in the long run. The effect of the Income support policy

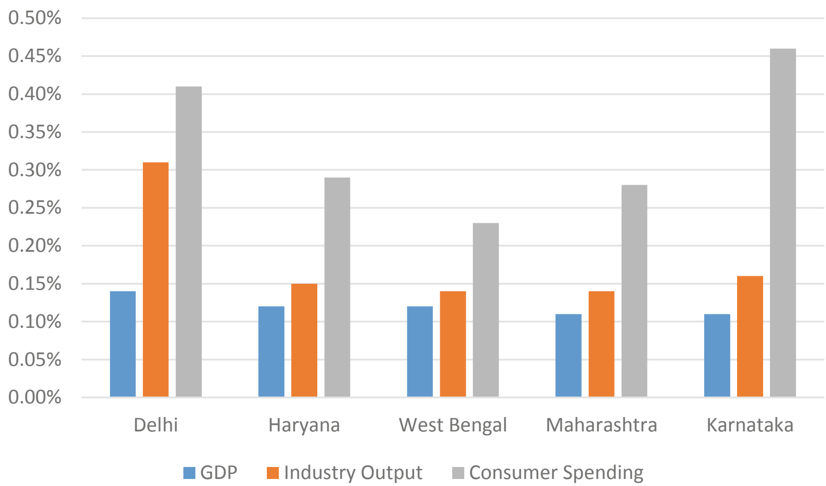

Fig. 10.5 Average percentage difference from baseline for GDP, Consumer spending and industry output (2020–28) (*Source* Results from the model)

can be better captured by looking at the trends in Consumer spending since these benefits generally translate into higher consumption levels.

The industry output increases due to stimulated spending through increased money in the hand of the people. This money is more reflected through direct benefit transfer as the employee provident fund contribution under the scheme has more impact on the regular saving habit of the people. The Consumer spending invariably is higher among the top-performing state and Union territory in comparison to the industry output. While Delhi shows the relatively highest growth in industrial output, the Consumer spending is relatively higher. Although, it must be noted that the gap between the expenditure and output is the least in Delhi along with Haryana while it is quite large in other states. Tamil Nadu shows high Consumer spending but is not among the best performing states in terms of industrial output whereas Kerala shows up in the growth of industrial output but lacks behind in consumer spending. This observation can be related to various local factors. Kerala, although being the first state to witness the pandemic cases but its performance in controlling the cases is much better than the rest of the states. The states which are showing higher growth rates are strikingly among those which witnessed the worst-hit cases of the pandemic. However, besides pandemic, it is observed that the states with a higher burden of below poverty line groups like Chhattisgarh, Jharkhand, Bihar, Uttar Pradesh continue to fall back in terms of an overall increase in consumer spending. These states struggle with the poverty groups and at the same time, have a large population to feed. This indicates that the policies need to be directed in such a way so that already lacking states are not further left behind in reaping the benefits of schemes to the poor. For further comprehensive picture, disaggregated Consumer spending is shown in Table 10.7.

From Table 10.7, It can be seen that the Average of the percentage difference in Consumer spending is maximum on liquid fuels, gas and electricity. The states which have dominated in previous indicators continue to do the same in the disaggregated observations as well. However, it must be noted that since the income support policy measures are provided to below poverty line groups to lower-income groups, most of the consumption that takes place in these categories are more on subsidised products. The households spend relatively more on the food and basic amenities which shows relatively modest growth. The top-performing states in food and drinks are Delhi, Karnataka, Maharashtra and West Bengal. Delhi and Karnataka continue to be among the top performers in most of the categories. The consumer spending on tobacco is relatively different from the other categories with Bihar and Madhya Pradesh among the top performers. The disaggregated consumer spending continues to show the same trend as seen at the aggregate level. This means that the government has to focus more on the poor states like Jharkhand, Bihar, Uttar Pradesh who have seen the influx of a large number of migrant labourers to even out the spread of benefits generating from the Atmanirbhar package in terms of income support to the

Table 10.7 Average percentage difference from baseline for Consumer spending (2020–28)

Sr. no	*Range*	*Sector*	*Consumer spending*
1	Less than 2%	Food, drink, electricity, tobacco, clothing, gas, medical liquid fuels	Delhi, Karnataka, Maharashtra, Haryana

Source: Results from the model

households. It is expected that gradually as the economy picks up, the migration may follow to the cities. But the past crisis has heightened the need to boost employment capacities and ease in providing support to such states in the long run. In Atmanirbhar Package 2.0 and 3.0, various benefits have further been released to boost the rural employment and provide income support through Rozgar Yojana. They may provide additional relief needed but, it must be made sure that the states have the capacity to benefit from such policies.

10.4.4 Scenario: RBI Liquidity Infusion

The RBI measures were motivated by monetary support to compliment the fiscal policy. The credit expansion that happens through Banking channels has a variable impact on various states depending upon the existing financial structure and profile of the respective states. It is generally believed that these measures have a way of penetrating in the economy through differentiated banking channels in the economy and priority sector lending, especially to target the sectors like Agriculture and allied activities, MSMEs, small scale manufacturing etc. In addition, ease in liquidity helps the Non-Banking Finance Institutions indirectly through support and helps banks in financing long term infrastructure projects or in the present situation the sustainability of industrial units, facing distress post COVID-19. To analyse the impact of RBI measures, the investment augmentation to the manufacturing sector for assessment of the policy, given that credit is provided to these. In this light, the impact of the policies has been analysed on the macroeconomic variables like Consumer spending, Industry output and Employment and Trade at state levels.

An average of GDP growth from the baseline over the given time period was found to be approximately 6% in the study which shows impressive growth post-COVID-19 in the long run. However, this aggregate growth rate may not capture the impact on the industry output and employment. The trend might fluctuate depending upon how well the Economic sectors recover from the slowdown. The pace of recovery will be the consequential effect of the pickup in demand in the market and the recovery of supply chain forces. Since the scenario has been developed through the manufacturing sectors investment, the GDP growth may have been influenced by the growth in the manufacturing output of the various sectors.

The purpose of the policy is to induce easy credit at affordable rates without squeezing in the liquidity and attract private investments. Expansion of industrial output results in the creation of more employment opportunities. However, this may vary in the category of industries and its distribution across the regions. From Fig. 10.6, it can be observed that the All India Industry output might grow at 5.37% on an average while industry employment grows only at 1.64%. The gap between the output growth rate and employment can be traced to the pattern of growth observed in Indian Economy for the past many years. The capital intensity of the industries is growing, depriving the opportunity to capture large-scale labour employment.

It is expected that the big states are likely to perform better due to their existing manufacturing units, financial infrastructure and outreach. The impact of the monetary policies varies across the states. In such a scenario it is important to look at the regional level impact. It can be seen that Punjab shows the highest growth among the states followed by Assam performing better than the rest of the North-Eastern States. Assam has been one of the strongest economies when looked at North-Eastern States performance in the past years. The bigger states like Punjab,

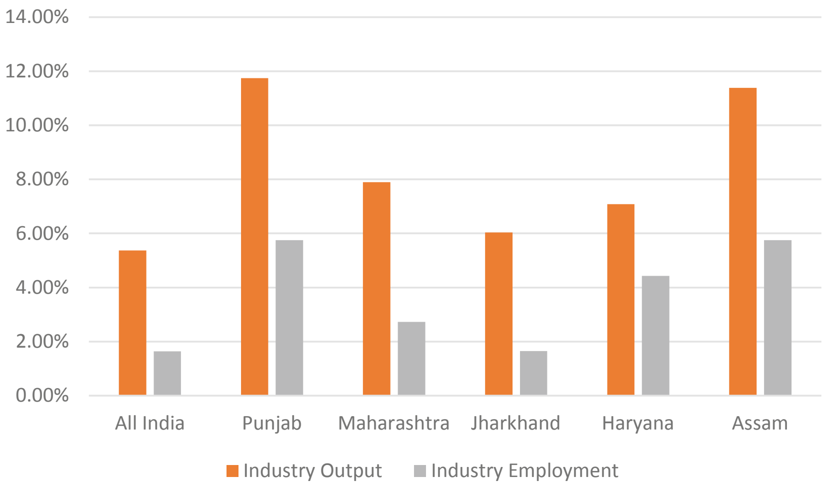

Fig. 10.6 Average percentage difference from baseline for industry output and employment (2020–28) (*Source* Results from the model)

Haryana, Maharashtra are performing fairly good in terms of industry output. These are some of the states with a good concentration of manufacturing units in terms of large industrial units and MSMEs. However, the proportion of the states like Odisha, Jharkhand, Assam, Chhattisgarh and Rajasthan which had been struggling with low levels of development in the earlier years, are coming up. This indicates that one might expect the RBI measures through financial outreach would help in bringing more regional level equity gradually. It can be further observed that there is a gap between the growth of Industry output and Industry Employment, indicating that in future, identification and incentive to labour-intensive industries may be required. Punjab shows the highest growth of industrial output at 11.75%, while the employment generated is almost half than this at 5.99%. Among the rest of the states, Assam and Haryana are the only two states except Punjab which are showing industrial output double that of the industrial employment. In the rest of the top-performing states, the employment growth is way less than the industry output, reaching up to five times less. However, positive growth rates of the industry output and employment is a better position in future post COVID-19. Further, employment in Indian economy has been largely generated by Agriculture and allied activities and small-scale manufacturing activities. A closer look at the change in industry output and employment for top-performing sectors will provide more insight which industries are likely to benefit more.

The important manufacturing sectors have been classified based on their range of growth, given the investment shock provided to it in this scenario. From Table 10.8, one can observe that most of the manufacturing sectors lie in the range of growth more than 30%. This does not necessarily mean that the employment levels generated by these manufacturing units have the same growth rates. Most of the manufacturing sectors' employment growth lie in less than 30% benchmark. This pattern has been observed between overall industrial sectoral growth and employment growth as well.

The manufacturing sectors under a 10% growth rate are manufacturing fuels and non-metallic products with similar employment growth levels. Generally, the manufacturing units for manufacturing fuels are concentrated around the oil and gas industries. However, the growth rates of the two sectors have huge variations as per Table 10.8. States of Odisha and Jharkhand which share a good base to the oil and gas industries show the highest performance in this particular sector. On comparison with oil and

Table 10.8 Average percentage difference from baseline for output and employment of manufacturing sectors (2020–28)

Range	*Manufacturing sector*	*Output*	*Employment*
Below 10%	Manufacturing fuels	Odisha Jharkhand	Odisha Jharkhand
	Non-metals and mineral products	Maharashtra Tamil Nadu	Tamil Nadu Assam
	Pharmaceuticals	–	West Bengal Andhra Pradesh Karnataka
10% to 20%	Pharmaceuticals	Andhra Pradesh Gujarat Maharashtra	Madhya Pradesh Chhattisgarh Haryana
	Chemicals	–	Andhra Pradesh Maharashtra Tamil Nadu
	Metal goods	–	Jharkhand Karnataka Rajasthan
20% to 30%	Basic metals	Punjab Madhya Pradesh Kerala	–
Above 30%	Oil and gas	Tamil Nadu Assam Andhra Pradesh	Tamil Nadu Assam Andhra Pradesh
	Other mining	Jharkhand Chhattisgarh Andhra Pradesh	Jharkhand Chhattisgarh Andhra Pradesh
	Chemicals	Punjab Chhattisgarh Chandigarh	–
	Metal goods	Assam Andhra Pradesh Odisha	–

Source Results from the model

gas based industries, these states are not among the high performers in the respective sector. Both the oil and gas industrial output and employment grow at an average rate of more than 30%. As per Invest India Data 2020, three companies–Indian Oil Corporation contribute the largest to India's total refining production from FY 2018–19. The concentration of IOC is largely in the states of Assam, Odisha, West Bengal belt. As per Table 10.8, Assam stands among the highest performing state in oil and gas based industries which are in line with the current standing of the state. The belt of Tamil Nadu and Andhra Pradesh also share good concentration of oil and gas based industries especially in regions of Vishakhapatnam and Tamil Nadu coastal belt (GOI, 2020). In respect to how COVID 19 has disrupted these industries the most, it is highly likely that support is given by the government in Atmanirbhar package and falling oil prices will benefit such industries.

The non-metallic and mineral industries gain the most in the state of Tamil Nadu and Maharashtra while the employment growth is highest among the state of Tamil Nadu and Assam. All these states have a good share of non-metallic minerals-based industries such as limestone, dolomite, mica and gypsum-based industries. The pharmaceutical industries which grew at more than 10% are showing a lesser growth rate of employment in these industries.

The state of Maharashtra, Karnataka and Andhra Pradesh has a cluster of pharmaceutical industries. The states which are coming out to be performing the best are among the same states with already existing clusters. This implies that existing bases benefit the most in this industry. Similarly, for most of the sectors shown in Table 10.8 like Mining, Metal Goods, Basic Metals, Chemicals show a similar pattern. The states performing the highest are among those states which have already existing high performing clusters. However, except motor vehicles and mining industries, the employment generated by the rest of the industries is less than the proportionate growth in the output for these industries. The above results show that through the average growth of these manufacturing units benefit from the Atmanirbhar package provided through RBI liquidity, the already existing clusters benefit the most from this injected liquidity while the states which have been lacking in such sectors still stay behind. These states may require additional domestic policies and financial infrastructure to attract investments in their manufacturing sector.

The benefits of the expansion of the manufacturing base have consequent effects on the increased household income via Consumer spending and indirect spillover effects generated through the service-based industries. For the comprehensive understanding, it is important to look at these two components.

10.4.4.1 Service-Based Industrial Performance

The provision of services is both the major factor influencing the growth of manufacturing sectors through indirect support and at the same time,

Table 10.9 Average percentage difference from baseline for service sector output (2020–28)

Growth range	*Sector*	*States with the highest performance*
Less than 10%	Gas supply	Assam, West Bengal, Maharashtra
	Communications	Haryana, Odisha, Jharkhand
10% to 20%	Water supply	West Bengal, Haryana, Jharkhand
	Trade and logistics	Assam, Odisha, Gujarat
	Air transport	Maharashtra, Haryana, Gujarat
	Banking and insurance	Assam, Odisha, Chhattisgarh
Above 20%	Electricity supply	Haryana, Jharkhand, Maharashtra
	Water transport	Punjab, Haryana
	Land transport	Gujarat, Maharashtra, Punjab
	Other business services	Assam, Odisha, Gujarat

Source Results from the model

grows as the result of the growth in the latter. This happens due to the inter-sectoral linkages established due to the necessity of basic services in manufacturing. In order to capture the effect of the RBI support to manufacturing whose growth will have a consequent effect on the growth of service industries, Table 10.9 categorises the crucial services as per their average of the percentage difference for the services output.

From Table 10.9, it can be seen that the gas supply and communications grow at less than 10% rate. Sectors like water supply, air transport, trade and logistics and banking and insurance grow at a range between

10 to 20%. The electricity supply, water transport, land transport and other business services grow at more than 20%. The states performing highest among these services are almost the same states which benefitted the most due to growth in manufacturing sectors in Table 10.8. The better-off states in this respect are Gujarat, Maharashtra, Haryana, Punjab and West Bengal. Odisha, Chhattisgarh, Jharkhand and Assam might be benefitting because of the growth of manufacturing output, especially in mining industries, metal etc. as seen in Table 10.8. One important observation from Table 10.9 is that the states of Assam, Odisha and Chhattisgarh are top performers in Banking and Insurance which shows the positive effect of Atmanirbhar in financial inclusion in states which have not been predominant in such sector. Land and Water transport show higher growth than air transport, primarily because of their wider usage. However, the states with already existing transport infrastructure tend to benefit the most while the backward lying areas still do not show up despite consistent efforts made to connect the distant areas. The transport sector, electricity supply, water supply is the most important factor in supporting the manufacturing industries. One might need to invest more in such sector to provide ease of doing business for manufacturing in the backward regions like North-Eastern States, Bihar, Madhya Pradesh, Rajasthan which are not showing up growth in the industrial output.

It is important to assess how the growth in manufacturing and services has impacted the regional income of the people. Consumer spending is an important indicator of expected demand in the economy in the coming future. It is used as a proxy for possible effects on the income of the people and their respective demand. One might expect that due to the reduction in the household income due to COVID-19, the demand might not pick up immediately but take few years to improve. From Fig. 10.7, it can be seen that growth in consumer spending at an All India Level maybe 2.29% which is quite low especially for the consumer-based economy like India. At the regional level, except Odisha, the states which have strong economies have more growth in the consumer spending. It can be expected that given the low employment rate in relation to the output, the expansionary policy might not benefit the household directly.

In the recent years, both the Government of India and RBI have launched various incentives to boost trade, especially the export sector. The Government of India has launched policies securing guarantees to the loans taken for exports to ease credit to such firms. Various structural reforms in taxation and single window clearance systems have been

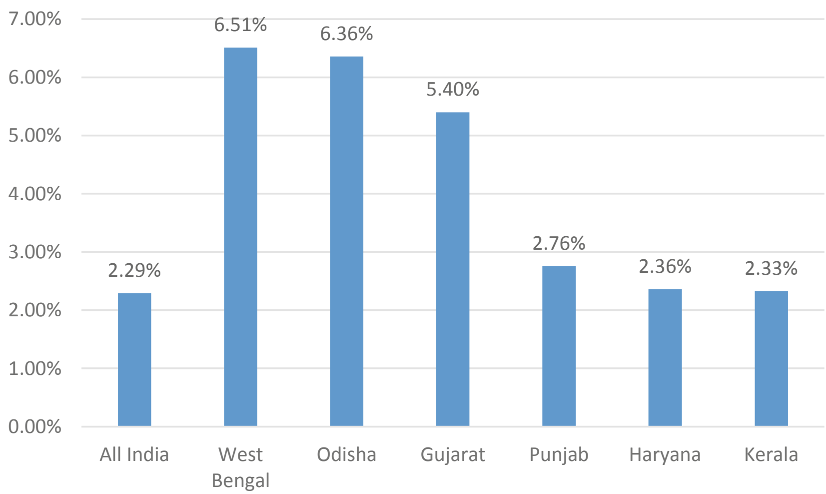

Fig. 10.7 Average percentage difference from baseline for Consumer spending (2020–28) (*Source* Results from the model)

introduced to boost the exports which at present, stands less than 2% of the global world exports (Government of India, 2019–20). RBI has categorised the loans given for purpose of exports as the priority sector lending. The ease in credit through Atmanirbhar package is likely to boost exports and reduce the dependence on imports as India strives for self-reliance under Atmanirbhar. It can be seen from the Fig. 10.8 that at an All India level, exports are likely to grow at 6.33% and imports little less than exports at 4.23%. The difference between the growth rates is not huge but given how the Indian trade has been performing since past decade, it provides a positive signal.

At the regional level, it is visible that mostly the states which have been performing better at trade, continue to perform similarly. Assam is the only North-Eastern state which has performed best in the given scenario and its growth in export and import can be attributable to the growing focus of the Government of India to link North-Eastern states to the South-East Asian trade and also, the traditional trade relations that have been pre-existing in commodities like tea, oil and gas, Agriculture products like horticulture crops. Mostly the coastal states are performing better in trade given their advantageous position in this respect.

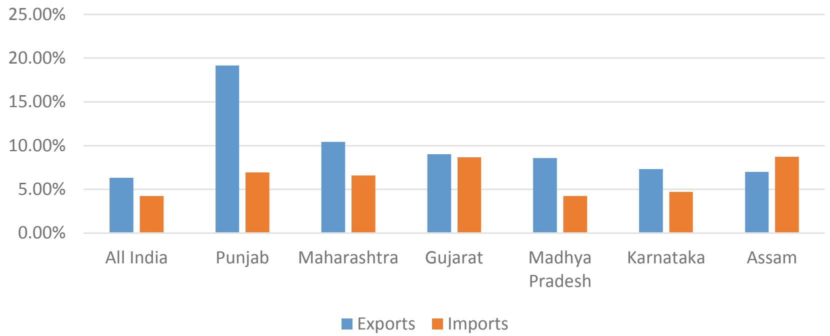

Fig. 10.8 Average percentage difference from baseline for regional exports and imports (2020–28) (*Source* Results from the model)

The overall analysis of the four scenarios shows that the sectoral impact may vary from state to state. These states show varying degrees of growth from the Atmanirbhar package due to the differences in their existing capacities to build up the potential growth pattern. Table 10.10 provides the summary of the overall results where the best performing states for different scenarios have been highlighted.

Table 10.10 highlights that the backward states are coming up mostly where the overhead investments are made in social and physical infrastructure. Thus, the directions of the Government of India to invest in capital infrastructure in the states would help in generating more equitable regional growth. Though the direction of the government through

Table 10.10 Summary of key performing states in each scenario

Sr. no	*Scenario*	*Top performer states*
1	Agriculture and MSME	West Bengal, Assam, Haryana, Andhra Pradesh
2	Physical and social infrastructure	Nagaland, Chhattisgarh, Odisha, Tripura
3	Income support policy	Delhi, Haryana, Maharashtra, West Bengal
4	RBI measures	Jharkhand, Maharashtra, Odisha, Assam

Source Results from the model

the additional packages is towards the same but, additional resources may be allocated for more widespread benefits. In addition, the states may invest in the potential manufacturing sectors through subsidised credit or interest subvention schemes, particularly targeting the potential sectors showing growth in the above scenarios.

10.5 Conclusion

The pandemic has shackled the economies across the world. In the light of disrupted businesses, increased unemployment and the crisis of the migrant labour, the social and economic implications of the pandemic have highlighted the already existing cracks. The worst affected groups among the population have been the poor and lower to middle-income groups. They have been largely employed in the informal sectors of the Indian Economy. These sectors lack adequate social security and financial services at an affordable rate to the people. The informal sectors like Agriculture and MSMEs depend on their regular income to keep them working. An All India lockdown was imposed as a measure to curb the spread of the pandemic, which brought the economic activities to the halt. This caused the fall of the regular income of the people and choked up their savings and working capital of small businesses. The governments across the world adopted various measures to help revive the economies. The Government of India launched the Atmanirbhar package amounting to USD 285 billion (INR 20 Lakh Crores) to boost up the economy and help the poor and vulnerable sections of the country. It adopted both the fiscal and monetary expansion measures to inject the liquidity in the society by making easy credit available to the people at affordable rates. The direct benefit transfer has been exhaustively used to reach the below poverty line groups for the sustenance of their basic needs along with the distribution of subsidised rations.

This chapter provides the assessment of the policies provided under the Atmanirbhar package 1.0 released in May 2020. The entire package has been categorised into four different scenarios to understand the working of different sectors under the given policy more comprehensively. The infusion of the package may happen at different periods of time but, the model assumes 3 years period. Variation in injection may impact short-term growth but the long-term growth that has been assessed using the E3-India model shall remain less affected from the time period differences. **Furthermore, Atmanirbhar package 1.0 is the largest package**

amounting to USD 285 billion (INR 20 lakh crores) compared to 2.0 and 3.0 packages with a combined USD 128 billion (INR 9 lakh crores). The additional monetary support may lead to difference in the magnitude of impact across states, but the trend will remain the same as shown in this chapter. It has been analysed that the regional growth in terms of output and employment expansion happens in all the four scenarios with the highest growth happening in scenario 4 which is the RBI monetary expansion. It could be possibly because of the more direct route of financial credit to the selected sectors. The bigger states like Punjab, Haryana, Gujarat, Maharashtra, Kerala and West Bengal are performing fairly good in terms of regional growth. These are some of the states with a good concentration of manufacturing units in terms of large industrial units and MSMEs. However, the proportion of the states like Odisha, Jharkhand, Assam, Chhattisgarh and Rajasthan which had been struggling with low levels of development in the earlier years, are coming up. This indicates that one might expect the RBI measures through financial outreach would help in bringing more regional level equity gradually if additional policies and schemes could be put into place along with public infrastructure and services. The financial credit provided to MSMEs and Agriculture has benefited the states which have been doing relatively better than the rest of India over the years like Haryana, Uttar Pradesh, Gujarat, Andhra Pradesh, West Bengal and Assam. The spread is uneven across all India level. This highlights the need for additional institutional mechanisms in the states like Bihar, Jharkhand, North-Eastern states as these have a high proportion of the underdeveloped regions with huge potential for Agriculture and processing industries and MSMEs. The fiscal measures like the investment in Physical and Social Infrastructure have a long gestation period. The growth can be seen in the backward states like Chhattisgarh and Jharkhand, North Eastern and hilly regions. The consumer spending, industrial output and employment have seen a modest increase. The states have benefited from the infrastructure development and through backward and forward linkages resulted in the expansion of the manufacturing sectors as well. For future reference, infrastructure development must be given a priority in fiscal measures, especially when the policies are targeted for all-inclusive development. The direct income support policy in this line is directed at the below poverty and lower to middle-income groups. This has benefitted mostly the states with existing financial services in better form. The targeting measures of states that have performed relatively better in this scenario are much better. This highlights that the financial infrastructure of the backward states must be expanded and its expansion will aid in better supplying of services. However, since these were to meet the basic needs of the poor in the pandemic, the regional GDP and industrial output growth are less. The consumer spending has increased in the big states and UTs like Delhi, with the largest growth of consumer spending on liquid fuels. In all the four scenarios, West Bengal and Assam have performed relatively better. The understanding of their local factors would help in identifying the key reasons why these states are performing better than the other states.

The common phenomena observed in all the four scenarios is that though the high growth can be observed for the manufacturing and service sectors, the employment at both all India level and regional level is almost half of the output growth. For this, the Government of India might have to induce investments in labour-intensive sectors. The trade expansion has been seen largely in big states and those near the coast, highlighting the need for expansion of transport services to the small and hilly regions. The cluster-based Agriculture and manufacturing growth would help in expanding the scope of food processing industries and ancillary services in the backward regions. The RBI liquidity infusion, when directed to the manufacturing sector, has resulted in a positive growth rate in comparison to other policies. Thus, the credit if appropriately directed to the manufacturing sectors will boost up the regional output and employment. The North East and backward states have performed the best when the investments have been made in the infrastructure indicating the lack of existing services in these regions. The public–private collaboration might be required to increase the provision of basic services to these sectors. More funding would be required for the Viability Gap Funding in infrastructure as the growth is modest but the results especially in the upliftment of backward and North-Eastern regions are positive. The results from the analysis of the policies are in line with the steps that the Government of India has been taking. The Government of India has announced the Atmanirbhar package 2.0 and 3.0 providing additional funding to some of the sectors. The financial support has been provided to the Ministry of Transport and defence equipment purchases along with interest-free loans to states for capital expenditure. Additional liquidity injection has been made to the DISCOMs to revive the electricity sector. One of the standout policy measures of the Atmanirbhar

3.0 package (November, 2020) is the additional expenditure on manufacturing linked production incentives worth USD 20.8 billion (INR 1.46 lakh crores). These target the diversified sectors of automobiles, electronics, textiles, advanced cell chemistry battery, pharmaceuticals, food products, high-efficiency solar PV Modules, white goods and speciality steel. It must be noted that these coincide with the manufacturing sectors chosen by the policy scenario under RBI measures. The direction of credit to these sectors would help in boosting the required output and employment. This will help in picking up the regional economy and gradually, can be extended to the backward regions through special state support. Additional capital expenditure linked incentives are required due to the poor infrastructural conditions which incurs additional costs for manufacturers. Additional amount to boost up infrastructure growth through capital industry, NBFC Debt Funds and income support measures for short term have also been provided under Atmanirbhar 3.0. In light of the recent pandemic events, GOI has provided additional USD 89.8 billion (INR 6,28,993 crores) support to revive the nation, with special focus on Medical and Health sector (PIB, 2021). In addition, the RBI has injected additional amount through monetary measures. The additional funding is much needed to support the infrastructure development and employment growth for the recovery of the economy from the pandemic. The implementation of the schemes launched under Atmanirbhar must be put into focus with cooperation from states and additional funding and investment from international sources. A periodical review of the working of the policies would help in understanding the further demand and direction of government support. The E3 State-level model could help in providing state-specific growth targets that can be possibly achieved with additional intervention for the future course of action.

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CHAPTER 11

Sub-National Policy Impact in India: An Integrated Assessment

Kakali Mukhopadhyay

11.1 Introduction

India has been one of the fastest-growing economies in the past few decades. But this growth has not been uniform across the country (Chancel & Piketty, 2017). This inequality can be attributed to the diversified physiography, varied natural resource endowment and different cultures and traditions influencing the local behaviour of people. These factors play an important role in determining how well a region adapts itself to different policies undertaken by the government to correct the structural rigidities present in the economy. For instance, policies that may work well for the skilled human resource in Kerala, may have a limited

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impact on regions like Bihar. Growing inequality and changing demography across India have therefore made the one-policy-fits-all approach redundant in the past few years. In such a situation, it is important to analyse the working of the regional economy and develop policies suited to those areas. Hence, the government of India is putting greater emphasis on competitive and cooperative federalism (ET Bureau, 2017).

Different regions in India have resorted to different developmental policies to accelerate their economic growth and improve their socio-economic standards. However, irrespective of the economic strata they belong to, all economic policies have inevitable consequences on the environment. Moreover, the scale of impact on the environment depends upon the economic endowments of the regions. Thus, national commitments under the Paris Climate Agreement and the Sustainable Development Goals (SDGs) have to be fulfilled keeping in mind the regional contribution as different states should be mandated to take responsibility in accordance with the level of emissions resulting from their economic policies.

This book has focused largely on the recent policies undertaken in the primary, secondary and services sector along with the energy-environment dimensions, at the national and sub-national levels, and compared the regional growth prospects resulting from these policies. Chapter 1 gave a brief summary of all the chapters while Chapter 2 described an overview of the state-level macroeconomic E3-India model to provide a foundational understanding of the framework. The E3-India model helps to capture the state-level impact of national and sub-national policies by providing growth forecasts for various macroeconomic variables. Chapter 3 elaborates on the data preparation methodology and the sources referred to for constructing the E3-India model. Chapters 4–7 analyse the Government policies targeting the major sectors of the economy. Across these chapters, the COVID-19 impact and the environment dimension have been captured for a comprehensive analysis. Further, Chapters 8 and 9 evaluate policies framed dedicatedly for the environment-energy nexus. In order to provide a realistic outlook in the wake of the current pandemic, Chapter 10 critically analyses how well different economic sectors react to the Atmanirbhar relief package announced by the Government of India to revive the economy amid the ongoing pandemic.

These chapters have undertaken sector-specific policy impact analyses across regions. These help in evaluating the working of the policies and the possible corrective measures that need to be taken in future. Furthermore, such corrective measures and innovative solutions can be explored from the policy point of view by encouraging regions to learn from policies undertaken by other regions. Even though different regions belong to different growth trajectories, similarities can be found in the pathways the regions adopted to reach a higher level of economic development. Such inter-regional studies at the sub-national level can assist in further regional cooperation and facilitate knowledge exchange for equitable growth of the nation.

Although the previous chapters have presented a regional analysis of sector-specific policies to highlight the nuances of regional variations in a particular sector, in reality, these sectors are highly inter-connected, with major bearing on each other's performance when implemented simultaneously in any given region. **In order to capture the essence of simultaneous working of multiple policies together in diversified sectors and areas of development, this chapter employs the E3 India model to analyse the results for various macroeconomic variables resulting from the working of diversified policies together**. The net impact would offer a diversified outlook to derive comprehensive policy insights. This will also help in tapping the potential of respective states as per their resource endowments and identify the sectors which can be interlinked through regional cooperation such that more equitable growth can be promoted. The regions which show significant impact for particular sectoral policies discussed in preceding chapters can show a different picture when looking at the net impact from the integrated scenario. This can help us in highlighting the skewness of the development process of a particular region which benefits from the growth of one or two sectors, but overall, at an aggregate level, lags behind in comparison to the rest of the regions.

The rest of this chapter is structured as follows: Section 11.2 gives a brief description of the scenario development undertaken to perform the integrated policy exercise, Section 11.3 discusses the results of the integrated scenario and based on the results, the recommendations for future directions has been provided in Sect. 11.4.

11.2 Scenario

The integrated scenario helps in analysing the effectiveness of these policies better through direct and indirect impacts on various other sectors.

The set of policies finalised for this exercise were selected in a manner to ensure that the resulting mix of policies were both representative of all major sectors of the economy and, relevant in terms of having a major bearing on the economy. Hence, those policies that yielded tangible impact in Chapters 4–10 were selected. In order to undertake a regional analysis of this comprehensive set of policies, major states have been clubbed into four main regions: East, West, North and South. This would help in identifying the zonal growth and provide a comparative picture of regional growth across the country. The states have been chosen on the basis of their performance in the aforementioned chapters. Moreover, most of these states have been common among the major policies selected for this exercise and also possess well-defined state-level sectoral policies in some cases. This would help in contrasting the results of the integrated scenario with that of the individual policy impact seen in the previous chapters. Table 11.1 provides the list of policies chosen for the exercise and the states chosen to represent each region.

The ten states chosen for this exercise together constituted nearly 68% of the nation's GDP in 2018–2019 and hence, are quite representative of the affairs of the country. Moreover, there is a marked variation across these regions in terms of their contribution to the national GDP. The Western region leads in this respect, accounting for nearly 23% of the national GDP and is closely followed by the South region, with a share of 21%. The North contributes nearly 17% while the East stands at a distant fourth position, contributing 8% to the national GDP (IndiaStat Database, 2019). This distinction implies that the results of the integrated scenario cannot be interpreted independently of the economy's size of the respective regions. The resultant regional performance across various indicators is presented in the next section.

11.3 Results

The macroeconomic variables have been evaluated to study the overall impact of the policies across the regions segregated by the zones. Figure 11.1 presents the average percentage difference from the baseline for different indicators over the period 2020–2030 to provide a long-term perspective. It must be noted here that these results are representative of the seven policies presented in Table 11.1 only. In reality, however, there may be a number of other policies at play, which might either complement or dampen the growth indicated by these results. Another caveat to

Table 11.1 Policies and States selected for the integrated scenario

Sr. no	*Chapters*	*Policy*	*Time period*	*East*	*West*	*North*	*South*
1	Chapter 4	Food Processing Industry	2018–2026	West Bengal, Odisha	Maharashtra, Gujarat	Rajasthan, Haryana, Uttar Pradesh	Andhra Pradesh (including Telangana), Karnataka, Tamil Nadu
2	Chapter 5	National Capital Goods Policy	2016–2025				
3	Chapter 6	Electronics Policy	2019–2025				
		Digital India Initiative	2019–2025				
4	Chapter 7	Automotive Mission Plan 2026	2016–2026				
5	Chapter 8	RE Capacity additions to match 450 GW of solar and wind installations	2020–2030				
6	Chapter 10	RBI Measures	2020–2022				

Source Results from the model and Author's calculations

be noted while interpreting these results is to consider the varying size of different regions' economy. This implies that an equal percentage increase in GDP relative to baseline across all regions will translate into an absolute increase that differs in magnitude across these regions. Considering the Eastern and Western regions, for instance, an equal percentage increase would imply a much larger absolute increase for the latter, simply due to the larger size of its economy.

It can be clearly seen from Fig. 11.1 that all the variables experience diverse impacts across the four regions. A closer analysis of each variable would help in capturing the different dimensions of growth across the regions.

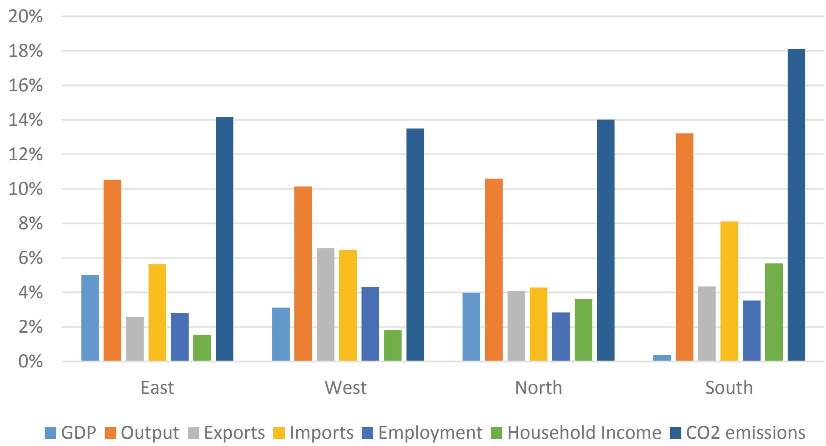

Fig. 11.1 Average percentage difference from baseline for macroeconomic indicators (2020–2030)—Integrated Scenario (*Source* Results from the model)

The East region shows the highest growth rate in *GDP* in comparison to the other regions while the South region shows a very minimal GDP growth rate. The growth in GDP for Western and Northern regions is close to 4%. Except the East region which is showing relatively higher growth rate at approximately 5%, the other regions are showing lower growth rate than expected. It is important to understand the pattern followed by the components of GDP and the likely reasons for the modest growth rates. The share of growth in GDP for the Eastern region has been contributed by the states of West Bengal and Odisha. The working population of both these states has been dominated by those engaged in the primary sector but the integrated policy shock may have helped in compensating for the manufacturing and services sector as well by creating backward and forward linkages necessary to push the GDP, output and employment through this scenario.

The growth in *output* is almost close to 10–12% for all the regions which show that there may be equality in terms of output growth across India, though the composition of this output might differ. The *employment* for all the regions is close to one-third of the output growth. This kind of growth pattern is similar to the pattern observed throughout the chapters in the book. The low employment growth in relation to output has been the characteristic feature of the Indian Economy for a long time (Kannan & Raveendran, 2019). Almost all the policies have a prime target of generating employment especially to reap the benefits of the demographic dividend, but the forecast reveals that more efforts need to be made to come out of the vicious cycle of jobless growth. This problem might aggravate the existing slowdown that has been ailing the Indian economy due to demand deficiency added to which, the pandemic has created additional problems of job loss and reverse migration (TOI, 2020).

The growth of an economy is truly beneficial if it is able to achieve its objective of increasing the welfare of its people. Increase in purchasing power is one such indicator of increase in welfare. This increase in purchasing power can spur higher demand, thereby further feeding back into the economic system. Choudhary (2020) puts emphasis on how the economic growth may rise in future only when the purchasing power can be restored in rural and urban regions by reviving the jobs that have been lost during the COVID-19 pandemic. Therefore, the *household income* variable is used as a proxy to evaluate the impact of the integrated scenario on welfare across regions. This would help in directly understanding how well the economic growth is getting translated into growth at the household level. It is crucial to understand that there is an inherent lag in household income growth as the output expansion benefit takes time to reach the hands of the people. The growth in household income is less than 2% in East and West regions while North and South regions show a higher growth of 3.6 and 5.7% respectively, which is even higher than the employment levels in these two regions. The Northern region might be experiencing higher household income because of better average GDP growth than the others. Hence, the transition of investments into employment and household income is better in such rich states as the reach is high.

Trade forms an inevitable part of the highly integrated global economy of the present times. It plays an important role through expansion of the markets for goods and services by leveraging economies of scale. All the sectors, especially the manufacturing sector, have been aimed to increase exports for the Indian economy. Figure 11.1 shows that there has been a tangible growth in both exports and imports but imports have risen more than exports, except in the West region where the difference is marginal. In the North region, imports are marginally higher than exports and are growing at the modest rate of 4%. Exports in the East region is the smallest among all while its imports show almost the double growth rate. This could be because the states in the Eastern region have been characterised by the dominance of informal/unregistered economic units which are not well integrated into the regional value chains. Another such region where imports are double than exports is the Southern region, where the magnitude of import growth is quite high as compared to the other regions. The high imports might have pulled down the GDP growth in this region as the output component of GDP is growing at an impressive rate. In this context, the qualitative difference between the high imports of the Eastern and the Southern region needs to be highlighted. The National Innovation Survey, 2014 had found that the most important innovation related activity that India divulges in is the acquisition of machinery, equipment and software (through imports) and the three states representing the Southern region (along with Maharashtra) are the most innovative states in the country (NSTMIS, DST GOI, 2014).[1] Thus, while the imports of the Southern region are catalysing its innovation potentiality, improving the nation's overall performance on the Global Innovation Index,[2] the same cannot be said for the Eastern region. Hence, **imports need to be analysed from a qualitative perspective as well, by looking at *what*is being imported rather than being fixated on *how much* is being imported. The composition of the trade basket influences the growth pattern at the regional level**.

It is also important to evaluate the growth of an economy through the lens of the environment for more comprehensive results. With the consequences of climate change seen very tangibly across the globe, it has become imperative that all the countries, irrespective of the development trajectory they might belong to, pursue environmentally sustainable economic policies. In order for India to meet its commitment towards the Paris Agreement or the SDGs, the contribution at the regional level is going to play a pivotal role. It can be seen from Fig. 11.1 that with an increase in economic activity, there has been a rise in CO_2*emissions* in all the regions, with the growth rate ranging from approximately 15 to 18% on average. Although there is not much regional variation in the average growth of CO_2 emissions across regions, the Southern and the Western regions report the highest and the lowest growth

[1] Details in Chapter 5.

[2] India ranked 48 among 131 countries in the recently released Global Innovation Index, retaining its position as the most innovative country among Central and South Asian countries (GOI, 2020).

in emissions, respectively. This result is particularly concerning for the Southern region when evaluated against its performance in the individual policy scenario where the states of Andhra Pradesh & Telangana, Tamil Nadu and Karnataka had added the maximum renewable capacity as well as registered the highest reduction in coal generation by 2030.[3] This contradiction is indicative of the inter-linkages being experienced in the integrated scenario, such that the proposed RE capacity addition fails to compensate for the emissions produced as a result of the other economic policies in place. Therefore, to meet its pre-determined commitments, more efforts need to be made to reduce the CO_2 emissions by effectively stepping-up the proposed shift to cleaner sources of energy.

11.3.1 Regional Analysis

The pattern followed by the variables discussed above has inter-linkage effects of the various policies which have been studied as individual cases in the previous chapters. To understand the trend of these variables and their economic impact, it is important to look at the regional analysis of such variables and possible factors behind their growth pattern. Table 11.2 highlights the region-wise strengths across all the policies considered for the integrated scenario. This can help explain the pattern of performance exhibited by different regions.

A detailed analysis of the varying regional performance is presented below:

1. *East*

   The growth in GDP in the East region has been the highest among all the regions. However, in the individual policy scenarios in the book, the case may not be the same for all sectors. As seen in the individual scenarios, **West Bengal has performed rather well in the case of Food Processing Industries (FPI).[4] Moreover, the relevance and impact of FPI is very high as it is ranked among the top three states in terms of GDP, Employment, Exports and Imports.** The other policy scenario which could have contributed to high GDP and output may be the liquidity infusion through RBI

[3] Details in Chapter 8.

[4] Details in Chapter 4.

Table 11.2 Region-wise Strengths for the Integrated scenario[a]

Sr. no	*Policy*	*East*	*West*	*North*	*South*
1	Food Processing Industry	✓ (WB)	✓ (MH)	✓ (RJ, UP)	✓ (TN)
2	National Capital Goods Policy		✓ (MH)	✓ (HR)	✓ (KN)
3	Electronics Policy			✓ (UP)	✓ (AP, TN)
4	Digital India Initiative			✓ (RJ)	✓ (KN)
5	Automotive Mission Plan 2026			✓ (HR)	✓ (TN)
6	RE Capacity additions to match 450 GW of solar and wind installations		✓ (MH)	✓ (RJ, UP)	✓ (AP, KN, TN)
7	RBI Measures	✓ (OR)	✓ (MH)	✓ (HR)	
	Integrated Scenario[b]		✓ (MH)	✓ (HR)	✓ (KN, TN)

[a]Notations in brackets indicate top performing states. AP: Andhra Pradesh (including Telangana), GJ: Gujarat, HR: Haryana, KN: Karnataka, MH: Maharashtra, OR: Odisha, RJ: Rajasthan, TN: Tamil Nadu, UP: Uttar Pradesh, WB: West Bengal
[b]Combined Impact of Policies 1–7 in Table 11.2
Source Results from the model

where West Bengal is among the top-performing states in pharmaceutical industries.[5] This might also be the underlying factor behind the boost showing up in the integrated scenario. The other state which contributes to growth in the East region is Odisha. Throughout the individual policy impact scenarios covered in the book, the impact on Odisha has been negligible except in a few instances which could help explain the growth. Through increased credit availability for various manufacturing industries, it has been seen that the manufacturing fuels sector in Odisha exhibits impressive growth.[6] Odisha being one of the richest states in terms of natural resource endowment such as iron, coal, bauxite, manganese, nickel and many more, it therefore has the potential to expand in terms of refining and upstream petroleum products (Dash, 2019).

[5] Details in Chapter 10.

[6] Details in Chapter 10.

As a result, the state has an existing robust infrastructure built over the last several decades to support the manufacturing fuels and exploration and refining in the oil and gas sector. Since these industries are highly capital-intensive sectors, the availability of credit plays a pivotal role in the operations of such industries. The scope of amplifying the potential exhibited by Odisha through regional stimulus to its capital goods sector was also highlighted earlier.[7] The RBI liquidity infusion therefore helps in catering to these shortages. It must be noted that since the liquidity infusion in RBI is made through a boost to the manufacturing sector, the same may be reflected in the integrated scenario, where the liquidity infusion into manufacturing might boost the growth in GDP, output and employment in the other sectors as well. West Bengal and Odisha are also the top two states with the largest increase in consumer expenditure in the RBI policy scenario.[8] This implies that the consumer expenditure might be growing in individual policy but the household income growth in the long run is not as much as one would expect. Probably, the limited impact of other policies may have slowed down the increase in household income. The East region results show that it is the highly specialized sectors of these states which have contributed substantially towards their GDP. However, the inter-sectoral gap remains high and lags behind relative to other regions in terms of employment, income level and exports. This is because sectors such as automobiles, Digital India initiative or electronics sector have lower penetration in the region relative to the other three regions which show cumulatively higher percentage shares of the aforementioned sectors. Barring a few sectors such as the FPI in West Bengal and the Manufacturing fuels sector in Odisha, there is limited or no diversification otherwise.

2. *West*

The Western region shows moderate GDP growth though the output expansion is high. Both household income and the employment growth are low. The West region has been largely dominated by the rich states such as Gujarat and Maharashtra. One might

[7] Details in Chapter 5.

[8] Details in Chapter 10.

expect greater GDP growth in these states due to their performance in the past but the GDP growth remains close to 2.5% on average. This trend is in line with the results seen for individual policy scenarios in the previous chapters, i.e. although these states have been among the top contributors throughout, their contribution remains incommensurate when seen in comparison with their share in the national economy. It is therefore important to understand the probable sources compelling the growth of the respective states. The trade for this region is growing at an average growth rate of 6% per annum with exports and imports being nearly equal. Maharashtra has performed relatively well across several indicators in the FPI scenario except trade.[9] Meanwhile, Gujarat, which has the second-largest share of processed agricultural exports, exhibits higher imports than exports. Thus, an increase in food processing output not only accentuates the rate of growth of processed food exports, but also that of imports of complementary products to increase the output of the domestic FPI industry (MOFPI, 2020). This may explain the pattern observed in the integrated scenario as well. The other reasons for this growth could have been the output growth seen in the electronics sector, large increase in exports for the capital good industries and the impact of RBI liquidity infusion on the manufacturing sectors. Both the states have been the prime focus point for automobile industrial growth in the past but, it has been highlighted in the previous chapters that the growth is slowing down due to reliance on imports.[10] The moderate performance of the states might continue to push up the growth but it may eventually taper off as the states fail to translate the growth into household income and employment growth. This may ultimately slow down the growth as the long-term impact of policies wear off and the market potential for these states shrink due to domestic factors.

Moreover, while the results from the sector-specific impact assessment undertaken in the previous chapters show that Gujarat and Maharashtra are the leading contributors relative to other states in the western region, it is to be noted that the magnitude of contribution of Maharashtra far outweighs that of Gujarat. This has also

[9] Details in Chapter 4.

[10] Details in Chapter 7.

been highlighted earlier, by depicting the reach of the national policies concerning the capital goods sector across different states.[11] It is only in the last few years that Gujarat has shown substantial progress in sectors such as the FPI or the automobile sector. However, Maharashtra has been the leading state in terms of contribution to the national GDP as well as in various macroeconomic indicators since the beginning of the twenty-first century and continues to do so even today. Furthermore, Maharashtra has recently announced an ambitious target of becoming a USD one trillion economy by 2025 and achieving 20% share of National GDP from the current level of 15% (PTI, 2018). Such an ambitious target is achievable for Maharashtra because it has highly diversified sectors which contribute significantly to the state's GDP. As we have seen in the previous chapters, **Maharashtra significantly contributes across the agriculture, manufacturing and services sector, thus making it the leading economy in the country.** On the other hand, Gujarat, though has similar sectoral policies operational, it remains at a distant second place in the Western region.

3. *North*

   The North region shows almost moderate growth of approximately 4% in GDP, employment, imports, exports and household income and close to 10% growth in terms of output. The states representing this region have been among the top performers in the individual policy scenarios. One of the possible reasons behind this growth could be **growth led by output expansion in FPIs for all the three states, namely Uttar Pradesh, Rajasthan and Haryana.** Uttar Pradesh and Haryana have been the agriculture hub of the country for many decades and this seems to be projected in the future too (PHD Research Bureau, 2019). Uttar Pradesh saw the largest increase in employment in FPI while Rajasthan also experienced a considerable impact.[12] This impressive employment expansion might be the source of employment growth in the integrated scenario as well although the rates are smaller than the individual policy. Both Uttar Pradesh and Rajasthan are net importers in the processed food industry which explains the higher

[11] Details in Chapter 5.

[12] Details in Chapter 4.

imports than the exports. The other factors underlying the growth in the region may be the growth led by Uttar Pradesh in the Electronic sector where it is the leading state with the largest share of national output. **Haryana stands out as the leading automobile hub with high positive impact across output, employment, consumer spending and exports.** However, imports also increase to a higher degree thus indicating high import dependence. Haryana also emerged as the leading state in the capital goods sector, in terms of reaping the maximum benefits from the national-level policies concerning the sector.[13] The state may also see an increase in exports of electrical engineering and manufacturing-led growth due to RBI liquidity infusion.

4. *South*

   The South region has shown the highest increase in its output and household income among all the regions. The output expansion of the region may be due to the contribution made by Tamil Nadu in the manufacturing sectors such as FPI, electronics and automotive. Andhra Pradesh may have seen growth in output and employment expansion in the electronics sector and exports expansion in the capital goods sector. **Both Tamil Nadu and Andhra Pradesh have shown growth prospects for non-metals and mineral products, pharmaceuticals, and mining sectors.**[14] **In case of Karnataka, exports of capital goods might spur the growth as well as its contribution in the Digital India initiative.** The southern region sees the largest increase in output as well as household income not only because of the presence of various manufacturing industries but also from the large service sector base due to the existing IT infrastructure. The southern states have performed relatively better than the rest of the country in terms of literacy rates and poverty levels. As a result, the adoption of digital services as well as transition from brick-and-mortar businesses to e-commerce has been at a faster rate. Thus, with increase in manufacturing activity as well as digital adoption, the increase in household income is also the highest in the South. Despite good performance of the other variables, the GDP growth is the lowest in

[13] Details in Chapter 5.

[14] Details in Chapter 10.

this region. This could be because of the high import dependence which has dragged down the GDP. In addition, it has been seen that while in the regions of North, all the states have high state-level growth but, in South, Tamil Nadu is the highest contributor and other states have moderate performance. This explains why the aggregate may be low.

There have been differences in the performance of the individual and integrated scenario results because of the nonlinear nature of the model. This helps in capturing the inter-linkages created by the growth in various sectors. The integrated scenario helps in capturing the realistic picture and how well the results suit the policy objectives. Across the macroeconomic indicators such as Output, Employment, Exports and Household Income levels, we see that Southern and Northern Regions have outweighed the results for the Eastern and Western regions. This is because the Southern and Northern states have shown robust results across the diversified sectors, thus showing more balanced growth. On the other hand, the high GDP growth in the East region may have been because of the high specialisation in a few sectors. The West region results are single-handedly represented by the results for Maharashtra to a large extent. This regional variation helps in understanding the relative potential of the sectors which can help in designing appropriate regional policies.

11.4 Concluding Remarks and Recommendations

India has been a recipient of economic benefits arising from the globalised economy leading to inter-linkages across the country for flow of goods and services. India is integrally a part of GVCs across key manufacturing sectors. However, in a country as large as India, there are a large number of inter-regional linkages within the country which have been built up to meet the requirements of GVCs as well. This study helps in analysing which states have been performing better in integrated and diversified scenarios, the potential areas of growth if proper implementation is done, comparison of the regions to understand the comparative advantage they enjoy and the lessons they can learn from each other.

It can be seen from the results of the previous chapters and the integrated scenario that in certain sectors, few states are performing better while the same may appear to experience limited impact of the other policies.

The East region results indicate that **West Bengal has been benefitting from the development of FPI and manufacturing through credit expansion by RBI**. Odisha shows growth when the credit accessibility is increased in the region which may lead to expansion of mineral resource-based industries. This highlights that these states must focus on the infrastructure development and provision of ancillary services to boost up the regional-level output and employment growth and increase the trade potential in the region via good transport connectivity and easier trade norms for the exports of primary resource-based industries.

In the West region, **Maharashtra can be seen performing well across diverse sectors ranging from FPI and Capital goods to RE capacity installation**. Meanwhile, to boost up the potential for **Gujarat, further opportunities need to be created in other diversified areas such as automobiles, renewable energy and equipment**. Both these states have huge capacity for renewable energy development through setting up of wind power, solar power and hydel power. These states also have pre-existing knowledge of traditional trade and the same experience can be utilised to boost up the trade for new sectors and help in better linkage to the GVCs.

The **Northern and Southern states** have been performing relatively better than the other regions especially in the **automobiles, capital goods and services generated through the Digital India initiative**. This highlights that the Northern and Southern states might be benefitting because of the success of the efforts made into setting up manufacturing and services sectors in the past few years. Haryana has contributed the most in manufacturing of automobiles and capital goods for the past decades and may continue to show positive growth for the same as evidenced by the study undertaken. The importance of the sectors influencing each other can be seen since it has been among the top performers in most of the scenarios. Karnataka has been considered as the IT hub but in the scenarios, it has performed much better in agriculture exports and manufacturing of automobiles. It has in the past put a lot of emphasis on the state-level policies for developing the infrastructure required for electricity access and human capital formation. Gujarat which has relied on traditional industries so far may learn these lessons from the Southern region to diversify. Rajasthan, which has been among the BIMARU[15] states, has been performing much better in the scenarios because of its efforts in the IT sector and Digital India initiative. These sectors must be further encouraged through regional level policies for these states to further boost their development.

The government of India needs to focus on better implementation of the policies in the short run. During this time, the sectors showing potential for high growth in the respective region must be given a boost. The pandemic has paralysed the economic activities which have hampered the output and employment expansion. The focus on the potential sectors would help these sectors in picking up growth at a faster rate and bringing it on the path of recovery. This will help in generating the interlinked growth prospects for the other sectors in the regions. In the medium term, the government of India must focus on diversification across the states. However, different states have to realize their potential depending upon the degree of capital and labour mobility within their states as well as the endowment of natural resources they have. Thus, states such as Odisha cannot follow the same policies as that of Maharashtra or Tamil Nadu as currently it is not endowed with the resources which the latter states have. Nevertheless, it can optimize the resources that already exist within the state which is the Oil & Gas sector which has tremendous scope of attracting investment and mobilizing resources. On the other hand, a state such as Gujarat is not as diversified as some other states, however, the results have shown that they still have a high potential for growth and diversification across sectors. Such a situation can be considered as a case study where they can learn in terms of policy-making from the bigger states such as Maharashtra, Karnataka or Tamil Nadu since they belong to the same economic growth trajectory, but at separate points in time. It is important to diversify the sectors for employment generation and special focus has to be made on labour-intensive industries to break the vicious cycle of jobless growth. One such labour-intensive sector that exhibits immense potential across all regions and should be targeted in the immediate short run is the FPI. The mutual cooperation of the national policies and convergence of regional policies with the national targets would help in realising the potential of the regions. Furthermore,

[15] An acronym for Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh, coined in the 1980s, to represent states which lag behind in terms of various socio-economic indicators (FE, 2018).

diversification should not imply mutual exclusivity, where only different manufacturing or different service sectors are targeted. States need to diversify across agriculture, manufacturing and services sectors. This can be seen for the South and North region by the virtue of which they consequently outperform East and West regions. In the case of Karnataka, we can see that it benefitted the most through the expansion of IT-BPM sector post-1991 reforms such that it is considered as the leading IT hub in the world. However, it has diversified its economy across agriculture and manufacturing sectors as well. It is also host to a number of capital goods industries and has recently prospered in the automobile sector, setting an example for the rest of the country by becoming the first state to design a comprehensive Electric Vehicle and Energy Storage Policy 2017 (ET Bureau, 2018). Thus, Karnataka also stands as a case study for other states, where diversification can lead to higher economic development of the state.

In the medium to long term, the focus should be on developing and strengthening the Regional Value Chains (RVCs) within India and across countries. These value chains provide states immense potential for diversification and development of multiple sectors. There have been enough policies targeting all the sectors of the economy, especially the manufacturing sector, yet India's growth in the past has been dominated by the services sectors. This could be because of a lack of adequate resources to sustain that growth. This can be worked upon by working on the inter-linkages. The Southern regions have performed better because of good linkages and connectivity both within the region and with the world. This has to be incorporated for the other regions for better supply of inputs and output. There is a need to build on structured and formal value chains through infrastructure development. The informal stigma needs to be overcome by bringing in better regulatory and implementation mechanisms and training of the workforce. The large unskilled workforce needs to be given appropriate training to work in the modern sectors of manufacturing and services. This would help in reaping the benefits of the demographic dividend and at the same time, serve as a global supply of skilled labour to other nations.

In a country as large as India, with different states endowed with separate economic and geographic characteristics, formulating policies to strengthen RVCs can lead to more equitable growth of states across the four regions. **Since the liberalization policy of 1991, sectoral growth amplified in few states more than the others due to the natural**

resources and human capital they were endowed with which were nurtured over the years. For example, IT sector in Karnataka, Automobile sector in Tamil Nadu and Haryana, Electronics sector in Uttar Pradesh etc. Thus, an increase in demand in any particular sector leads to flow of goods and services across states.

There needs to be more studies on inter-regional cooperation and RVCs that play a significant role in defining the scale of inter-regional and international trade. With more thorough studies of such inter-regional linkages, better transfer of resources from surplus states to deficit states can be understood with subsequent impact on international trade as well. More studies need to be undertaken in order to analyse the inter-industry linkages such that the RVCs can be established and made more efficient. Meanwhile, any tangible impact to be delivered from the current exercise awaits **proactive measures from policymakers who need to revisit the existing national policies and realign them with the short, medium and long run requirements and capacity of different regions.**

While the advanced states like Maharashtra, Karnataka and Tamil Nadu are in a position to take up diversified policy action in the short run and direct resources to expand their markets through further integration in the GVCs, the same cannot be true for states like West Bengal, Bihar and Odisha that are still dependent on a few specialised sectors. These states can only think of such policies in the medium to long run, that too with sustained policy support in terms of investment in both infrastructure and capacity building, abiding by the lessons demonstrated by the experience of the former set of states. Till then it is best to leverage the specialised sectors of these states, with policy support to integrate them into robust RVCs to derive maximum gains from the resultant linkages. Gujarat presents another example where regional policy must be tailored to suit its need for diversification in the short run, given that the state has been able to deliver better on the infrastructure front as compared to other states in the East. The **expansion of the domestic capacity across the regions based on their potential of output and employment growth would facilitate boosting the input requirement resulting in lower reliance on imports**, even for the rich states. **This would help in reaping the benefit of the economies of scale through well-connected RVCs which would make India truly self-reliant and in the long term, a global hub of trade.** Shaping these regional insights into deliverable policy actions ultimately lies in the hands of the policymakers who need to prioritise a decentralised approach to cater to the needs of regional evidence-based policymaking, thereby strengthening and leveraging India's unique diversity as she progresses towards achieving more and more ambitious targets.

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